San Francisco–Oakland Bay Bridge
East Span Seismic Safety Project

Marine Foundation Removal Project
2017 Post-Blast Environmental Report

EA 04-013574

EFIS#: 0416000287

04-SF-80 KP 12.2/KP 14.3

04-ALA-80 KP 0.0/KP 2.1

March 2018

California Department of Transportation

Caltrans

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The environmental review, consultation, and any other actions required by applicable Federal environmental laws for this project are being, or have been, carried out by Caltrans pursuant to 23 U.S.C. 327 and the Memorandum of Understanding dated December 23, 2016 and executed by FHWA and Caltrans.

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List of Abbreviated Terms

°C	degrees Celsius
°F	degrees Fahrenheit
μPa	micro Pascal
BAS	blast attenuation system
Bay	San Francisco Bay
BCDC	San Francisco Bay Conservation and Development Commission
BO	Biological Opinion
CCSF	City and County of San Francisco
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
CFGC	California Fish and Game Code
cSEL	cumulative sound exposure level
CTD	conductivity-temperature-depth
dB	decibel(s)
DC	direct current
Delta	Sacramento–San Joaquin Delta
Demonstration Project	Pier 3 Demonstration Project
Department	California Department of Transportation
ESA	environmentally sensitive area
FESA	Federal Endangered Species Act
GPS	Global Positioning System
Hz	hertz
IBR	International Bird Rescue
IHA	Incidental Harassment Authorization
ITP	Incidental Take Permit
mg/L	milligrams per liter
mm	millimeter
MMEZ	Marine Mammal Exclusion Zone
MMO	marine mammal observer
MMPA	Marine Mammal Protection Act
mph	miles per hour
ms	millisecond(s)
NGVD29	National Geodetic Vertical Datum of 1929
NMFS	National Marine Fisheries Service
NTU	nephelometric turbidity unit
OTD	Oakland Touchdown
psi	pound per square inch
psi-ms	pounds per square inch-milliseconds
PTS	Permanent Threshold Shift
RWQCB	Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SF Basin Plan	San Francisco Bay Water Quality Control Plan

SFOBB	San Francisco–Oakland Bay Bridge
SFOBB Project	San Francisco–Oakland Bay Bridge East Span Seismic Safety Project
SMP	Self-Monitoring Program
S/s	samples per second
SWPPP	Storm Water Pollution Prevention Plan
TMMC	The Marine Mammal Center
TTS	Temporary Threshold Shift
UAV	unmanned aerial vehicle
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
WDR	Waste Discharge Requirement
WQO	Water Quality Objective
YBI	Yerba Buena Island
ZOI	zone of influence

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Executive Summary

This Marine Foundation Removal Project, Draft 2017 Post-Blast Environmental Report presents the background, methods, and results of environmental resource monitoring, performed during marine foundation removal at Piers E6 through E18 of the original San Francisco-Oakland Bay Bridge (SFOBB), as part of the SFOBB East Span Seismic Safety Project. The piers were removed during six controlled implosion events in fall 2017, as shown in Table ES-1.

Table ES-1. Fall 2017 Blast Event and Timing

Blast Event (BE)	Pier(s)	Implosion Date	Official Blast Time
BE1	E7 + E8	September 2, 2017	10:36 a.m.
BE2	E6	September 16, 2017	10:00 a.m.
BE3	E9 + E10	September 30, 2017	9:23 a.m.
BE4	E11 + E12 + E13	October 14, 2017	8:51 a.m.
BE5	E14 + E15 + E16	October 28, 2017	7:49 a.m.
BE6	E17 + E18	November 11, 2017	7:27 a.m.

To minimize and avoid impacts to biological resources in the San Francisco Bay (Bay), the California Department of Transportation (Department) implemented a number of avoidance and minimization measures, including the deployment of a Blast Attenuation System (BAS), a highly controlled blast plan and monitoring activities. The environmental resources that were monitored during each implosion event included: hydroacoustics/underwater pressure, marine mammals, avian species, fisheries, and water quality. Monitoring results from each of the resource categories indicate that avoidance and minimization measures, such as implementation of the blast attenuation system, consolidation of multiple piers into shared blast event, and seasonal avoidance successfully reduced impacts on environmental resources to levels below previously agreed upon thresholds.

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Chapter 1. Project Description and Background

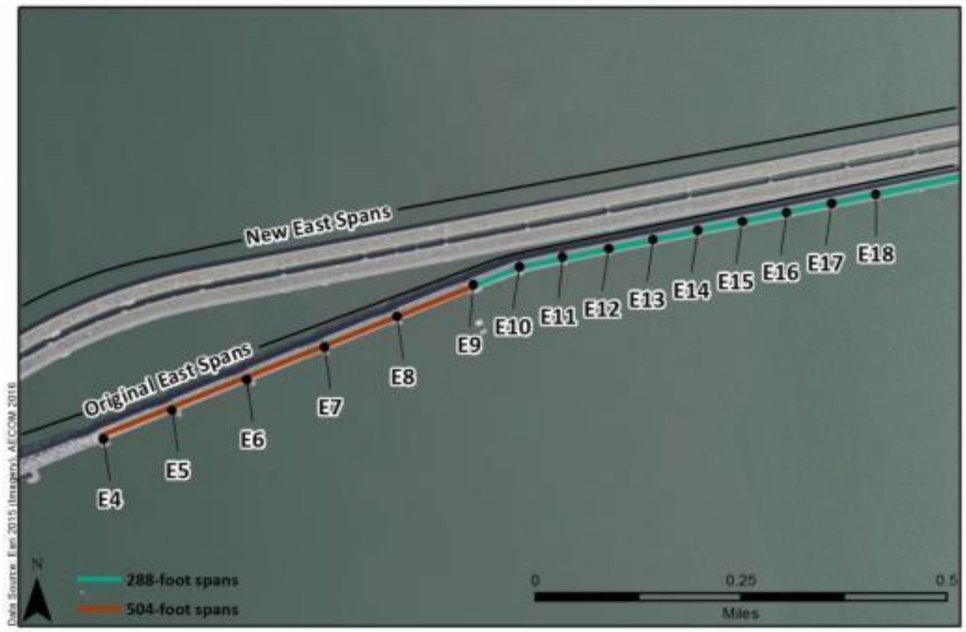
1.1. SFOBB Project Background Summary

The Department, as part of the San Francisco–Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project (SFOBB Project), is in the final stage of dismantling the original east span of the SFOBB. The Department successfully imploded Pier E3 in 2015 and Piers E4 and E5 in 2016 with highly controlled charges. Piers E6 through E18 were successfully imploded in 2017. Controlled implosion was implemented as an alternate method to the originally permitted mechanical methods for dismantling the remaining marine foundations, because it resulted in fewer in-water work days, reduced impact on environmental resources of the San Francisco Bay, and required a shorter time frame for completion. The successful implosion of the piers, as well as the results from hydroacoustic, biological, and water quality monitoring that was conducted during and following the implosions, demonstrated that the use of highly controlled charges was an effective and efficient method for removal of these types of marine foundations, with the least impact on the environment and biological resources. Based on the positive results from the removal of Piers E3, E4, and E5, the Department used controlled implosions in 2017 to implode Piers E6 through E18. This removal method reduced the originally proposed in-water work duration by a year. In 2017 some piers were imploded as multiple-pier implosion events such that thirteen piers were imploded during a total of six events within the implosion work window. During multiple-pier implosion events, two to three piers were imploded sequentially.

The project area is located in the Central Bay, between Yerba Buena Island (YBI) and the City of Oakland. The western limit of the SFOBB Project area is the east portal of the YBI tunnel, located in the City of San Francisco. The eastern limit is approximately 1,300 feet (396 meters) west of the SFOBB toll plaza at the Oakland Touchdown (OTD) in the City of Oakland.

Removal of the marine foundations of the original east span occurred within the jurisdictions of the City and County of San Francisco (CCSF) and the City of Oakland in Alameda County. Piers E4 and E5 were located within CCSF jurisdiction and were removed in October 2016. Pier E6 straddled the border that delineates the CCSF from the city of Oakland. Piers E7 through E18 were located in the city of Oakland. All piers were located between the OTD and YBI, and were situated south of the new east span bridge

(Figure 1-1). The elevation of the new east span in relation to the original east span is shown in Figure 1-2. Approximate locations of each pier are shown in Table 1-1.



Source: Compiled by AECOM in 2016

Figure 1-1. Locations of Original East Span Marine Foundations, Piers E4 to E18

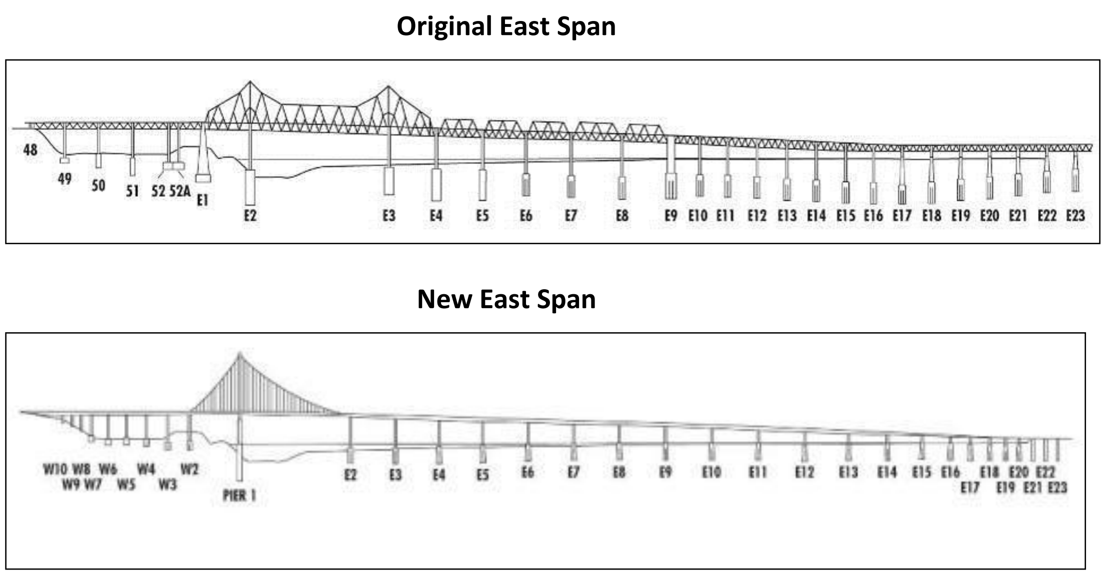


Figure 1-2. San Francisco–Oakland Bay Bridge Pier Locations

Table 1-1. Location Details for Remaining Marine Foundations of the SFOBB Original East Span

Pier Number	Approximate Distance to YBI		Approximate Distance to OTD		Approximate Coordinates
	Feet	Meters	Feet	Meters	
E6	3,058	932	5,511	1,680	37º 49' 02.38"N, 122º 20' 56.93"W
E7	3,580	1,091	5,008	1,526	37º 49' 04.23"N, 122º 20' 50.90"W
E8	4,070	1,241	4,504	1,373	37º 49' 06.18"N, 122º 20' 45.14"W
E9	4,590	1,399	4,001	1,220	37º 49' 08.13"N, 122º 20' 39.17"W
E10	4,897	1,493	3,688	1,124	37º 49' 09.24"N, 122º 20' 35.57"W
E11	5,185	1,580	3,404	1,038	37º 49' 09.83"N, 122º 20' 31.97"W
E12	5,478	1,670	3,110	948	37º 49' 10.43"N, 122º 20' 28.43"W
E13	5,765	1,757	2,818	859	37º 49' 11.00"N, 122º 20' 24.90"W
E14	6,053	1,845	2,526	770	37º 49' 11.56"N, 122º 20' 21.25"W
E15	6,343	1,933	2,232	680	37º 49' 12.06"N, 122º 20' 17.69"W
E16	6,628	2,020	1,951	595	37º 49' 12.64"N, 122º 20' 14.19"W
E17	6,923	2,110	1,666	508	37º 49' 13.24"N, 122º 20' 10.68"W
E18	7,216	2,199	1,376	419	37º 49' 13.75"N, 122º 20' 06.97"W

Note:

OTD = Oakland Touchdown; YBI = Yerba Buena Island

Source: Compiled by AECOM in 2016

1.2. Physical Conditions

1.2.1. Climate and Topography

The Bay is the largest estuary along the West Coast of the United States and is characterized by a Mediterranean climate. Generally, the climate is defined as having a dry season in summer and fall, followed by a wet winter. However, a variety of features—ranging from coastal mountain ranges, inland valleys, and smaller bays within the larger Bay—create unique local climates. Coastal areas typically are cooler than inland areas, and northern portions of the Bay generally receive more rainfall than southern areas. The average high temperature in San Francisco is 63.7 degrees Fahrenheit (°F) (17.6°Celsius [°C]) and the average low temperature is 51.1°F (10.6°C).

1.2.2. Hydrology

The SFOBB Project area is located within the Bay's hydrological region. Fresh water from the Sacramento and San Joaquin rivers enter the Bay at the Sacramento–San Joaquin Delta (Delta) before being carried into the Pacific Ocean through other portions of the Bay. Outflow from these rivers varies seasonally with rainfall and releases of managed reservoirs and diversions located upstream.

Generally, freshwater outflow into the Delta (and into the Bay) is greatest in spring and lowest in late summer and fall. Furthermore, this interaction between freshwater outflow from the Delta and tidal conditions influence the salinity gradient in the Bay. In turn, numerous fish and wildlife species change their spatial distribution in the Bay, in response to changes in this salinity gradient.

The SFOBB Project area is located in what generally is considered to be the Central Bay. The Central Bay is the deepest basin, is most influenced by the ocean, and has the saltiest water (on average) in the Bay. The deepest point is over 300 feet (100 meters) deep, near the Golden Gate Bridge. The Central Bay has the most marine species in the Bay and likely has the highest species diversity.

1.2.3. **Substrate/Sediments**

The sandy sediments in this portion of the Bay are understood to be sourced from shoreline sediments from outside the Bay, or from the Sierras via San Pablo Bay. Sediments in the Central Bay are estimated to be up to 100 meters thick. Most of the Bay in the vicinity of Piers E6 through E18 is made up of small, soft particles that can be moved by tidal currents. The sediments range in size, from clay (0.001 to 0.0039 millimeter [mm]) to silt (0.0039 to 0.0625 mm) to sand (0.0625 to 2 mm). Larger particles, including gravel (2 to 64 mm) and cobble (64 to 256 mm) also can be found in the soft-bottomed habitats. Sand deposits can be found throughout the deeper parts of the Central Bay and the main channel through San Pablo Bay. Strong tidal currents along the Bay floor make it a dynamic environment, with significant alteration and movement of sediments over time.

1.3. Regulatory Context

The original approvals for the SFOBB Project authorized and required dismantling of the original east span and were obtained in 2001 from the U.S. Coast Guard (USCG), United States Army Corps of Engineers (USACE), the United States Coast Guard (USCG), the California Department of Fish and Wildlife (CDFW), United States Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), the RWQCB, and Bay Conservation and Development Commission (BCDC). The initially proposed method of removal included traditional mechanical dismantling only. Removal of marine foundations to 1.5 feet below the mudline is required by USCG, in Bridge Permit 3-01-11, condition number 7 and the San Francisco (BCDC) (Permit No. 2001.008

[formerly Permit No. 8-01]). The Federal Environmental Impact Statement (FEIS), completed by the Department in 2001, stated that the marine foundations would be removed.

In 2012, the Department requested and received authorizations from regulatory agencies that included driving piles to build temporary trestles and falsework and facilitate dismantling of the original east span. Discussions with regulatory agencies were initiated in 2012 and to address potential removal of the marine foundations using controlled blasting.

1.3.1. **2015 authorizations for the Pier E3 Demo Project**

In 2015, the Department requested and received regulatory agency approvals and authorizations from the USACE, USCG, CDFW, the RWQCB, and BCDC for the use of controlled blasting to dismantle the Pier E3 marine foundation as a demonstration project (Demonstration Project). As part of these approvals, federal Endangered Species Act (Section 7) consultation was reinitiated by the Department with the NMFS, to determine and obtain coverage for potential impacts on federally protected fish species. A new Biological Opinion (BO) (NMFS 2015) was issued to cover potential impacts to listed species, their critical habitat, and Essential Fish Habitat from the Demonstration Project. This BO was in addition to the SFOBB Project's pre-existing BO (NMFS 2012). Furthermore, the Department requested and received from NMFS Office of Protected Resources (NMFS-OPR) a new Marine Mammal Protection Act Incidental Harassment Authorization (IHA), specifically for the Demonstration Project. Two letters of Modification to the original USACE Individual Permit were issued by the USACE for the project. CDFW issued the Project an amendment to the original Incidental Take Permit (ITP). Water Quality impacts from the Pier Demonstration Project were covered under a RWQCB accepted Storm Water Pollution Prevention Plan (SWPPP). The Project's BCDC permit was also amended for the Demonstration Project.

1.3.2. **2016 authorizations for the use of Pier E4-18 in 3 seasons**

On February 29, 2016, the Department received concurrence in a letter from USCG for proposed limits of removal of Piers E2 and E4 through E22. In spring 2016, the Department requested and received approval to remove Piers E4 to E18, using similar methods from the same agencies listed above. Approvals included a new consultation and BO from NMFS, a new IHA from NMFS-OPR for the removal of Piers E4 and E5 in 2016, a Letter of Modification to its USACE Individual Permit, and an amendment to its existing CDFW ITP. Water Quality impacts were covered under the RWQCB accepted SWPPP. Two amendments were issued to the SFOBB Project's existing BCDC permit.

1.3.3. 2017 amendments and approvals for Piers E6 through E18

In 2017, the Department requested and received approval from the agencies to conduct multiple blast events to dismantle Piers E6 to E18, during which multiple piers (up to four) would be removed in sequence during the same event, and to extend the approved post-blast clean-up window from December 15 to December 31. These approvals included a letter of concurrence from NMFS and an errata sheet to the 2016 NMFS BO, a new IHA from NMFS-OPR for removal of Piers E6 through E18, a Depredation Permit (MB57490C-0) from USFWS to use an unmanned aerial vehicle (UAV) (e.g., drone) as a pre-blast bird deterrent, a Letter of Modification to the USACE Individual Permit, an amendment (No. 6) to the existing CDFW ITP, and an amendment to the SWPPP. This effort was covered by the existing BCDC permit, as amended.

1.4. Mechanical Preparation and Removal

The first step in the pier removal process required mechanical removal of above-water pedestals that sat atop each of the remaining pier's caps, above the water. Mechanical removal operations for Piers E6 through E18 differed from the previously completed mechanical dismantling (Piers E3 to E5) because these piers did not have support aprons, fender systems, and/or did not require lowering of structural walls. The concrete pedestals were dismantled mechanically using wire saws, excavators mounted with hoe rams, drills, torches, and cutting tools, to an approximate elevation of +9 feet National Geodetic Vertical Datum of 1929 (NGVD29). Each remaining pier contained two hollow concrete pedestals, with the exception of Pier E9. Pier E9 contained four solid concrete pedestals. After the above water pedestals were removed, all remaining structures had vertical boreholes drilled into them, where the charges were loaded for controlled blasting.

1.5. Pier Implosions

Before the blast events, controlled charges were loaded into the bore holes of the pier to be removed. The boreholes varied in diameter and depth, and were designed to provide optimal efficiency in transferring the energy created by the controlled charges to dismantle the piers. Charges were arranged in different levels (decks) and were separated in the boreholes by stemming. Stemming is the insertion of inert materials, such as sand or gravel, to insulate and retain charges in an enclosed space. Stemming allowed more efficient transfer of energy into the structural concrete for fracturing and further reduced the release of potential energy into the adjacent water column. Individual cartridge charges, using electronic blasting caps, were selected to provide greater control and accuracy in determining the individual and total charge weights. Use of individual cartridges allowed a refined blast plan that efficiently broke the concrete while minimizing the amount of charges needed. Maximum individual charge weights used at each pier ranged from approximately 20 to 35 pounds. The total charge weights for each controlled blast event varied and are shown in Table 1-2.

Table 1-2. Pier Implosion Details for Piers E6 through E18

Blast Event	Piers	Blast Date	Blast Time	Approximate Explosive Charge Weight per Event (pounds)	Approximate Blast Event Duration per Event (seconds)
1	E7+E8	September 2, 2017	10:36 a.m.	8,880	5
2	E6	September 16, 2017	10:00 a.m.	15,500	7
3	E9+E10	September 30, 2017	9:23 a.m.	8,120	4
4	E11+E12+E13	October 14, 2017	8:51 a.m.	5,680	4
5	E14+E15+E16	October 28, 2017	7:49 a.m.	5,520	4
6	E17+E18	November 11, 2017	7:27 a.m.	4,000	3

Source: Compiled by AECOM in 2017

To minimize impacts on biological resources, controlled blasting events to remove Piers E6 through E18 were conducted during high slack tide in the fall months of each construction season (i.e., September, October, or November), using a blast attenuation system (BAS). As shown during the Pier E3 Demonstration Project (Demonstration Project) and the subsequent implosions of Piers E4 and E5, the BAS decreased noise and pressure waves, generated during each controlled blast, and minimized potentially adverse effects on nearby biological resources. The BAS is a modular system of pipe manifold frames, placed around each pier and fed by air compressors to create a curtain of air bubbles.

Between September 2 and November 11, 2017, the Department successfully executed the controlled implosions of Piers E6 through E18. Blast events, including timed delays between pier implosions for multiple-implosion events, lasted approximately 3 to 7 seconds, depending on the pier being removed or pier grouping. During multiple pier blast events, the spacing between the last charge on one pier and the first charge on the next pier was approximately one-half of a second, providing enough time between blasts to avoid accumulating peak sound pressure waves. Details for each blast event are shown in Table 1-2.

Public safety measures were implemented during the controlled implosion events. Safety zones were established and enforced, in conjunction with the California Highway Patrol and CDFW to exclude marine traffic not directly involved in the implosion. Safety procedures, roadway traffic management in both directions on the SFOBB, and complete closure of public access to the bike path/pedestrian walkway in advance of each controlled implosion were implemented successfully.

1.6. Post-Implosion Cleanup and Demobilization

Following each controlled blasting event and after receiving confirmation that the area was safe for work, construction crews removed all associated equipment, including barges, compressors, the BAS, and blast mats. Rubble from Piers E6 through E18 was removed down to each pier's respective, planned, debris removal limit elevation by a barge-mounted crane with a clamshell bucket. The clamshell bucket was equipped with a Global Positioning System (GPS) unit, to accurately guide the movement of the bucket during underwater operation. Post-blast debris management for all piers was completed before November 30, 2017.

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Chapter 2. Monitoring Programs Background

2.1. Monitoring Programs Background

To minimize impacts on biological resources and determine the level of hydroacoustic noise from the implosions, the Department implemented several monitoring efforts, including hydroacoustic pressure monitoring, marine mammal monitoring, avian monitoring, fisheries monitoring, and water quality monitoring. The monitoring efforts were developed and compiled in the *SFOBB Marine Foundation Removal Project–Final Biological Monitoring Programs* (2017 Biological Monitoring Program) (Department 2017b). The 2017 Biological Monitoring Program was developed to meet the permit requirements of the project's NMFS BO, NMFS 2017 IHA, CDFW Incidental Take Permit (ITP) through Amendment No. 6, and BCDC permit through Amendment No. 41, and the San Francisco Regional Water Quality Control Board amended Storm Water Pollution Prevention Plan (SWPPP) Amendment 13 . The 2017 Biological Monitoring Program provided detailed monitoring strategies and protocols to be implemented during blast events. Monitoring protocols were developed with direct input from the SFOBB Project's environmental regulatory agencies, and the draft monitoring program was circulated to each of them for review and approval before finalization.

A brief summary of each monitoring program is presented next. Detailed monitoring results are presented in subsequent chapters of this report.

2.2. Hydroacoustics/Underwater Pressure Monitoring

A monitoring program was implemented to collect in-water noise and pressure data during controlled blasting of Piers E6 through E18. The purpose of the blast pressure and hydroacoustic noise monitoring were to verify and evaluate distances to specific fish, marine mammal, and diving bird noise impact criteria. The monitoring plan was outlined in the 2017 Biological Monitoring Program that described the monitoring for Piers E6 through E18 in detail.

2.3. Marine Mammal Monitoring

The Department was issued an IHA from NMFS (2017 IHA), pursuant to the MMPA, for behavioral harassment of and temporary injury impacts to California sea lion (*Zalophus californianus*), Pacific harbor seal (*Phoca vitulina richardii*), northern elephant seal (*Mirounga angustirostris*), northern fur seal (*Callorhinus ursinus*), harbor porpoise

(*Phocoena phocoena*), and common bottlenose dolphin (*Tursiops truncatus*), incidental to the controlled implosion of Piers E6 through E18 (NMFS 2017).

The Marine Mammal Monitoring Program was implemented to minimize injury and harassment to marine mammals, establish injury and harassment threshold criteria zones, and specify methods for monitoring and reporting marine mammal activity near the implosion area. The Marine Mammal Monitoring Plan, as part of the 2017 Biological Monitoring Program, was prepared in compliance with the requirements for implosion of Piers E6 through E18 under the 2017 IHA.

2.4. Avian Monitoring

The bird monitoring protocol for controlled blasting was implemented to ensure that protected species were not affected during the blast events. Monitoring protocols included monitoring a listed diving bird exclusion zone, pre-blast bird monitoring, implementation of hazing measures (i.e., percussive audio deterrents and drones), and post-blast monitoring.

A minimum of two monitors were present to monitor the avian watch zone for bird activity before each blast event. The two avian monitors were positioned on the bicycle and pedestrian pathway of the new east span.

Use of UAVs for hazing birds in the SFOBB Project area was approved through a Depredation Permit from the United States Fish and Wildlife Service (USFWS), issued to the Department for the SFOBB Project.

2.5. Fisheries Monitoring

The fisheries monitoring methods are described in the 2017 Biological Monitoring Program and included: 1) sonar-based surveys before each blast event, to assess the potential presence of fish assemblages in the project area; 2) bird predation monitoring, conducted immediately after each blast event to help assess the level to which fish were affected by the project; and 3) fish salvage to further assess diversity of fish affected by each blast event.

2.6. Water Quality Monitoring

The purpose of the water quality monitoring was to ensure that the Bay water quality and eelgrass beds were not affected beyond temporary impacts from implosion events, in accordance with the SFOBB Project's Water Quality Certification (401 Certification), WDRs, and the San Francisco Bay Water Quality Control Plan (SF Basin Plan). Preliminary findings from water quality monitoring during the 2017 implosion season are presented in Chapter 11. The final results will be documented in a separate report.

Water quality monitoring was conducted during the controlled implosions and subsequent cleanup activities. The contractor prepared a Storm Water Pollution Prevention Plan (SWPPP) for the implosions of Piers E4 through E18, which was submitted to the San Francisco RWQCB for review and was accepted on June 27, 2016. The SWPPP describes best management practices that are to be employed during the course of construction work, related to removing the remaining pier foundations. The SWPPP has been amended, as needed, to provide best management practices during the implosions of all piers.

Operations associated with controlled implosions have included both over-water and in-water activities. All activities with the potential to affect the Bay water have required monitoring, in accordance with Waste Discharge Requirements (WDR) for the SFOBB Project, issued by the San Francisco RWQCB on January 2002 (Board Order No. R2 2002 0011) (RWQCB 2002). Water quality monitoring for construction activities not specifically related to the controlled implosions was conducted, in accordance with Appendix B of the WDR, which included a Self-Monitoring Program (SMP) related to in-water construction activities. The purpose of the SMP is to document compliance with effluent requirements and prohibitions established for the SFOBB Project, and to facilitate self-policing by the Department for prevention and abatement of pollution arising from dredging, fill, and other activities that may affect water quality in the Bay. The SMP identifies Water Quality Objectives (WQOs) that must be met to stay in compliance with the RWQCB permits. The SMP outlines turbidity control measures, intended to protect eelgrass beds and other biological resources during in-water work, for work occurring within 3,280 feet (1,000 meters) of an eelgrass bed or sand flat, also known as environmentally sensitive areas (ESAs).

A separate Sampling and Analysis Plan (SAP) was developed for the 2017 implosion season (Department 2017a). The implosion SAP was based on the requirements in the WDR and the SMP, and was tailored to address specific constituents of concern related to explosives and the specific schedule required for the implosions. The SAP identified a robust and comprehensive monitoring strategy that was appropriately modified, depending on the piers being imploded and the location of the piers in relation to the established eelgrass beds in the vicinity (Department 2017a).

2.7. Hydrographic Survey and In-Fill Monitoring

At each pier removal location, the Department performed a hydrographic survey using side-scan sonar equipment before removal, immediately after removal, and following site cleanup. These surveys were performed to determine existing conditions before removal, verify that pier removal was achieved, and what, if any, additional debris management was required. Hydrographic surveys provided final verification that each pier was removed to its respective removal limit and confirmed that regulatory requirements were met.

In addition, the Department has committed to monitoring the sediment accretion at former pier locations, to verify that these areas are on a trajectory to naturally infill to surrounding mudline elevations over time. Scour pit sediment infill monitoring results at former pier locations also are included in this report. The Department's report provides an estimate of accretion based on results from the hydrographic surveys. The results summary will analyze and describe the change in area and estimated volume of sediment accretion, or infill, at each pier removal location. After these surveys are completed, the Department will discuss the findings with its partnering agencies, including the BCDC, the RWQCB, and USACE, to determine whether further monitoring will be necessary.

Chapter 3. Hydroacoustics/Underwater Pressure Monitoring Results

Hydroacoustic monitoring was performed during each of the blast events that imploded Piers E6 through E18. The purpose of the blast pressure and hydroacoustic noise monitoring were to verify and evaluate distances to specific fish, marine mammal, and diving bird noise impact criteria.

During most blast events, hydroacoustic/underwater blast pressure monitoring was conducted in two specific regions around the piers—the “near field” and the “far field—each with unique methods, approaches, and plans. The near field included measurements taken within 1,100 feet (335 meters) of the piers in the south direction, while the far field was made up of measurements taken at 1,500 feet (457 meters) and beyond to the north. Because of the high peak pressures expected within 500 feet (152 meters) from each blast event, pressure transducers were required for data acquisition, instead of the conventional hydrophones.

Far-field monitoring was not conducted for the final two implosion events. Because Piers E14 through E18 were similar in size to the piers imploded during the previous two- and three-pier blast events, conducting both near and far-field monitoring was not considered necessary. Only near-field monitoring was conducted, to assure results were at or below previous results.

3.1. Monitoring Methods

For all blast events, the instrumentation, acquisition procedures, and processing methods were similar to those used for Piers E3, E4, and E5, but with fewer total monitoring locations. The specific methods for both near and far-field regions are discussed next. The metrics necessary for comparison to the relevant fish and marine mammal criteria were peak sound pressure level, cumulative sound exposure level (cSEL), root-mean-square, and the acoustic impulse pressure in pounds per square inch-milliseconds (psi-ms). These metrics are fully defined in the 2017 Biological Monitoring Program.

3.1.1. Instrumentation

3.1.1.1. Near-Field Monitoring

Near-field monitoring for Piers E6 through E18 were conducted outside the BAS, unlike previous piers, where pressures from the implosions were measured within the BAS as well, at nominal distances ranging from 200 to 1,100 feet (60 to 335 meters) south of the piers. Because of the close proximity of the monitoring positions to the piers, when multiple piers were imploded in a single event, distances were measured from the nearest corner of the pier that generated the highest peak pressure.

At each near-field location of 500 feet (152 meters) or less, PCB 138A01 pressure transducers capable of measuring up to 1,000 psi were used. This type of transducer is capable of capturing acoustic frequencies greater than 1,000,000 hertz (Hz). Because of the design of these pressure transducers, no method was available for field calibration, and thus the manufacturer-supplied calibration was obtained within 6 months of the implosion events. In addition, Reson TC4013 hydrophones with an upper acoustic frequency range of 170,000 Hz were used at nominal locations of 500 feet (152 meters) and beyond.

The voltage signals proportional to pressure for all measurements were recorded by an eight-channel MREL DataTrap II high speed recorder, sampling at 1,000,000 samples per second (S/s) (one record per 0.001 millisecond [ms]), per the Near-Field Hydroacoustic Monitoring Plan as included in the 2017 Biological Monitoring Program (Department 2017b). With the expected rapid rise time of pressure from individual blasts in an implosion event, the sampling rate of 1,000,000 S/s was determined to be appropriate for capturing the true peak pressures.

3.1.1.2. FAR-FIELD MONITORING

The nominal distances for the far-field monitoring positions were 1,500, 3,000, and 6,000 feet (457, 914, and 1,828 meters), as measured from the center point of the imploded piers. At each of these locations, Reson TC4013 hydrophones were deployed at depths ranging from 5 to 20 feet (1.5 to 6 meters), depending on the water depth at the monitoring positions. At all positions and during all implosions, the hydrophones were halfway between the water surface and the mud line.

The hydrophones provide a useful upper acoustic frequency range of 170,000 Hz. Signals from the hydrophones passed through PCB 422E04 in-line charge converters. For the 1,500-foot location, the frequency performance of the charge converters was enhanced to take full advantage of the 170,000 Hz upper range of the TC4013 hydrophones, by the use of PCB 482A22 signal conditioners that boosted the current supplied to the charge converters. These signals were recorded with Astro-Med, Inc. TMX multi-channel data acquisition systems, which captured the voltage signals proportional to pressure along the north monitoring array. These units record at a sampling rate of 800,000 S/s. The output of each system was split and fed into two or three channels of the recorder, each set to different voltage ranges to capture an optimal signal. The TMX systems were programmed to trigger by the incoming signal of the blast sequence. This trigger was manually armed by hydroacoustic monitoring personnel, located at the 1,500-foot (457-meter) position. The TMX system did not have internal electrical power and had to be powered at 24 volts direct current (DC) by two heavy-duty 12-volt DC batteries, connected in series.

Additional hydrophones were deployed at the 1,500-foot (457-meter) position and sent to a solid-state Roland R-05 audio recorder, sampling at 96,000 S/s. This provided a back-up to the high-speed recorder as well as a comparison between the two systems. Compared to the high-pressure transducers, the hydrophone systems are more sensitive, provide less electronic noise floor issues, and are more suitable for the lower levels estimated at distant locations.

At 3,000 and 6,000 feet (914 and 1,828 meters), unmanned autonomous units were deployed at least 1 hour before the implosion. These units consisted of a TC4013 hydrophone, a PCB 422E13 charge converter, and a PCB 480E09 signal conditioner, all housed in a water-tight cylindrical case about 5 inches (12.7 centimeters) in diameter and 12 inches (30.5 centimeters) long. The units were deployed on a rope with a weight on the end, near the container, and the other end secured to a line between a float and an anchored buoy that were positioned before the blast. The Roland recorders have sufficient memory so that triggering was not needed, because they can record continuously for up to about 12 hours.

3.1.1.3. CALIBRATION

The various pieces of equipment used for measuring the implosion required different calibration methods. For the PCB 138A01 pressure transducers, the sensitivities supplied by the manufacturer were used to convert the measured voltages into pressure versus time. The accuracy of the MREL DataTrap II and TMX recorders were supplied by the sources of the recorders. For the TC4013 hydrophones, direct calibration was possible, using a traceable pistonphone (calibrator). For these hydrophones, a G.R.A.S. 42AC Pistonphone, high pressure, Class 1 was used. This pistonphone was calibrated to produce a 165.3 decibels (dB) sound pressure level at 250 Hz, when used with a G.R.A.S. RA0078 Calibration Coupler for the TC4013. For systems using the Roland R-05 solid state recorder, the calibration tone was recorded directly and used to determine hydrophone sensitivities for the complete instrument chain, which in some cases included in-line attenuators to reduce the voltage of the signals going into the recorders. The resultant sensitivities are shown in Table 3-1.

Table 3-1. Summary of Resultant Sensitivities for Each Near and Far-Field Hydrophone

<table>
<tr><th rowspan="2">Pier Implosion Event</th><th colspan="6">Hydrophone Sensitivity (mV/psi)</th></tr>
<tr><th>S3, 500ft* or 800ft* (1,000,000 S/s)</th><th>S4, 800ft* or 1,100ft* (1,000,000 S/s)</th><th>N1, 1,500ft* (800,000 S/s)</th><th>N1B, 1,500ft* (96,000 S/s)</th><th>N2, 3,000ft* (96,000 S/s)</th><th>N3, 6,000ft* (96,000 S/s)</th></tr>
<tr><td>E7 + E8</td><td>918.846</td><td>N/A</td><td>317.775</td><td>N/A</td><td>397.219</td><td>1,125.453</td></tr>
<tr><td>E6</td><td>918.846</td><td>779.6345</td><td>370.738</td><td>N/A</td><td>423.700</td><td>1,138.694</td></tr>
<tr><td>E9 + E10</td><td>918.846</td><td>779.6345</td><td>582.588</td><td>635.550</td><td>4,104.594</td><td>16,948.001</td></tr>
<tr><td>E11 + E12 + E13</td><td>918.846</td><td>779.6345</td><td>820.919</td><td>N/A</td><td>9,400.844</td><td>26,476.064</td></tr>
<tr><td>E14 + E15 + E16</td><td>755.2585</td><td>779.6345</td><td rowspan="2" colspan="4">N/A</td></tr>
<tr><td>E17 + E18</td><td>755.2585</td><td>779.6345</td></tr>
</table>

Notes:

mV = millivolts

* These are the nominal sensor locations planned before the blasting events. The deployed sensor locations are shown in Figures 3-1 through 3-6.

3.1.2. Data Capture and Processing

3.1.2.1. Data Capture

To capture the near-field signals, the MREL DataTrap II high speed recorder used for data acquisition was triggered by the electronic signal used to initiate the blast sequence. In this manner, the recorder was time-synchronized, and the histories could be compared on a common time axis. For the far-field measurement at 1,500 feet (457 meters), data was recorded with the TMX high-speed recorder, sampling at 800,000 S/s. This was triggered by the in-water pressure signal from the blast itself, with a pre-trigger delay of up to 10 ms to be certain that the entire implosion event was captured. After each implosion event, the analog signals captured by Roland recorders at the other far-field locations were played back into the TMX high-speed recorder and sampled at 200,000 S/s to produce digital signals for analysis.

3.1.2.2. Data Processing

The near-field data pressure signals were acquired and analyzed by Contract Drilling & Blasting LLC, under the direction of Albert VanNiekerk, Ph.D. The far-field data was acquired and analyzed by Illingworth & Rodkin, Inc., under the direction of Paul Donavan, Sc.D. As part of the quality assurance and quality control process, both teams exchanged raw data and analyzed the other's results with their data analysis procedures. This resulted in consistent methods being applied to both data sets.

To compare results against appropriate marine mammal and fish sound criteria, the implosion's pressure signals were reduced and analyzed to obtain peak pressure level, impulse, and cSEL levels. The PCB transducers used at each near-field location were designed to capture the true peaks in signals with rapid rise times, and thus have inherent instrumentation noise. To produce comparable and usable results that were not inflated artificially by instrument noise, near-field data was processed using bandpass filters. Based on the signal, the high-frequency filter cutoffs used for the near-field analysis ranged from 50,000 to 100,000 Hz (low-pass filtering). A low-frequency filter cutoff of 10 to 20 Hz (high-pass filtering) was used to eliminate low-frequency excursions from zero that were not actually part of the blast signals. The hydrophone signals did not contain the high-frequency noise found with the PCB transducers and did not require low-pass filtering. The Roland recorders have internal high-pass filtering at 100 Hz.

3.1.3. **Data Analysis**

The dates of implosion and the start times for each implosion event are shown in Table 3-2. The high-speed recording systems (1,000,000 S/s) from the near-field locations were programmed to record for 6.5 to 9.5 seconds for each implosion event. The near-field time signatures were provided in pressure units of psi in a text-file format. The sampling rate of 1,000,000 S/s translated to more than 6.5 million lines of data for each implosion.

Table 3-2. Implosion Blast Dates and Times

Blast Event (BE)	Pier(s)	Implosion Date	Official Blast Time
BE1	E7 + E8	September 2, 2017	10:36 a.m.
BE2	E6	September 16, 2017	10:00 a.m.
BE3	E9 + E10	September 30, 2017	9:23 a.m.
BE4	E11 + E12 + E13	October 14, 2017	8:51 a.m.
BE5	E14 + E15 + E16	October 28, 2017	7:49 a.m.
BE6	E17 + E18	November 11, 2017	7:27 a.m.

The high-speed, far-field time signatures were set to record 4.5 to 10 seconds of data, and the data was exported in voltage units from the TMX device in text-file format. The medium-speed recordings (96,000 S/s) at the far-field locations were reviewed to isolate the implosion event. The wav-file containing the event was then re-recorded with the

TMX unit and then exported in voltage units to text file format. The TMX device was programmed to record at 200,000 S/s for the playback of these recordings.

Data were unfiltered (raw) and provided in psi for near-field locations and in voltage for the far-field locations. Optimum filter settings for the near-field signals were determined to report the peak pressures of the data in psi. All data were imported into LabVIEW and converted from psi to micro Pascal (µPa), using the 6.89 by 109 µPa/psi conversion factor. The far-field data was converted to µPa, using the sensitivities determined with the acoustic calibrator, as shown in Table 3-1, and the above conversion factor. The pressure versus time signals from the near-field and far-field monitoring locations were processed using the same algorithm to calculate the required metrics. Each metric (i.e., peak level, cSEL, and impulse) were calculated numerically, as described in the 2017 Final Biological Monitoring Program.

3.1.4. Measurement Locations

3.1.4.1. Near-Field Locations

The near-field monitoring plan consisted of three monitoring locations to the south during the implosion of Piers E7 and E8, and four monitoring locations to the south for each of the remaining events. Each of these monitoring locations was outside the BAS. Because of the sensors' closer proximity to the piers in the near field, distances were measured from each of the piers included in the implosion event. The PCB transducer was used at S1 and S2, while a hydrophone sensor was positioned at S3 and S4. The planned distances of 200, 500, 800, and/or 1,100 feet (60, 152, 243, and/or 335 meters) were used for each implosion event. The actual deployed locations for the near-field measurements during each respective implosion event are shown in Figures 3-1 through 3-6. Sensor depths were 10 feet (3 meters) below the water surface during the implosion of Piers E7 and E8, and 17 feet (5 meters) during the implosion of Pier E6. After Pier E6, the implosion events started moving closer to the Oakland shore, and the water depths got increasingly shallower. Therefore, for the remaining implosion events, sensor depths ranged from 8 to 10 feet (2.4 to 3 meters) for Piers E9 and E10, from 7 to 8 feet (2 to 2.4 meters) for Piers E11 to E13 and Piers E14 to E16, and from 5 to 7 feet (1.5 to 2.1 meters) for Piers E17 and E18.

3.1.4.2. Far-Field Locations

Far-field monitoring was planned at three additional locations along the north line, at 1,500, 3,000, and 6,000 feet (457, 914, and 1,828 meters). In addition, a second 1,500-foot (457-meter) measurement was taken during the implosion of Piers E9 and E10. Although near-field measurements were collected for each implosion event, far-field data was not taken during the last two implosions because two-pier and three-pier implosion events already had been measured. The deployed near and far-field measurement locations where usable data was collected for each implosion event are shown in Figures 3-1 through 3-4, respectively. Each of the far-field measurements was made with hydrophones 6 to 20 feet (1.8 to 6 meters) below the water surface. At 1,500 feet (457 meters), data was taken from a boat with the instrumentation operated by hydroacoustic monitoring personnel, while at the remaining far-field locations, unattended autonomous units were used to record the underwater data.

Successful measurements were taken at the locations shown in Table 3-3 for each implosion event. For each of the near-field locations, distances from each sensor to each pier are shown in Figures 3-1 through 3-6; however, because of the distances at which the far-field measurements were made, a single distance, as measured from the center point between each pier, is provided.

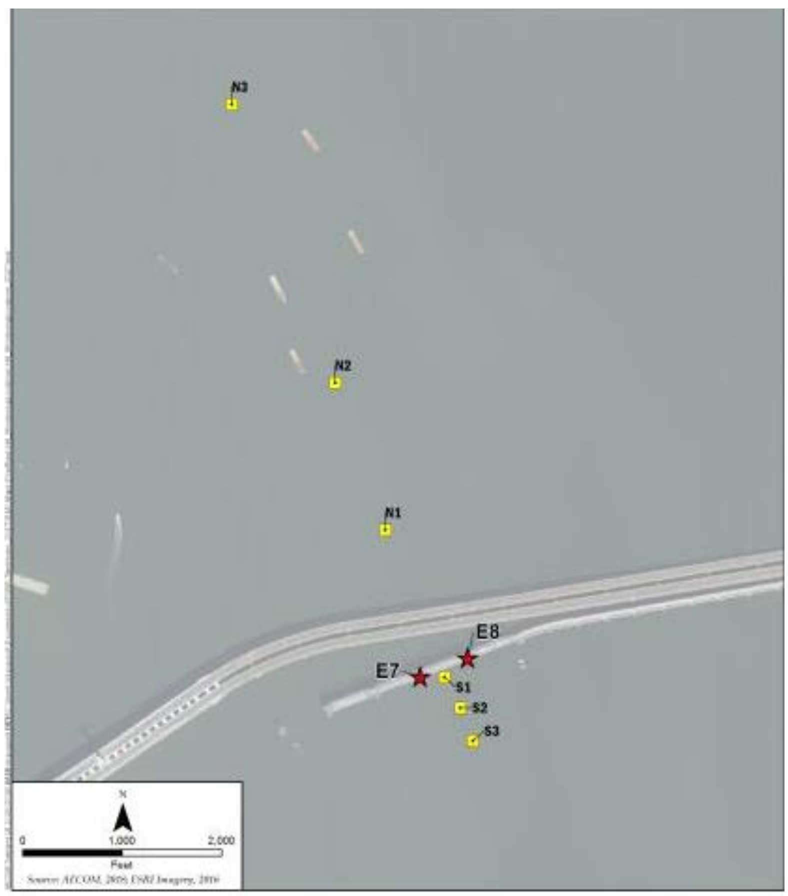

Figure 3-1. Deployed Near and Far-Field Locations where Data Was Collected during the Implosion of Piers E7 and E8

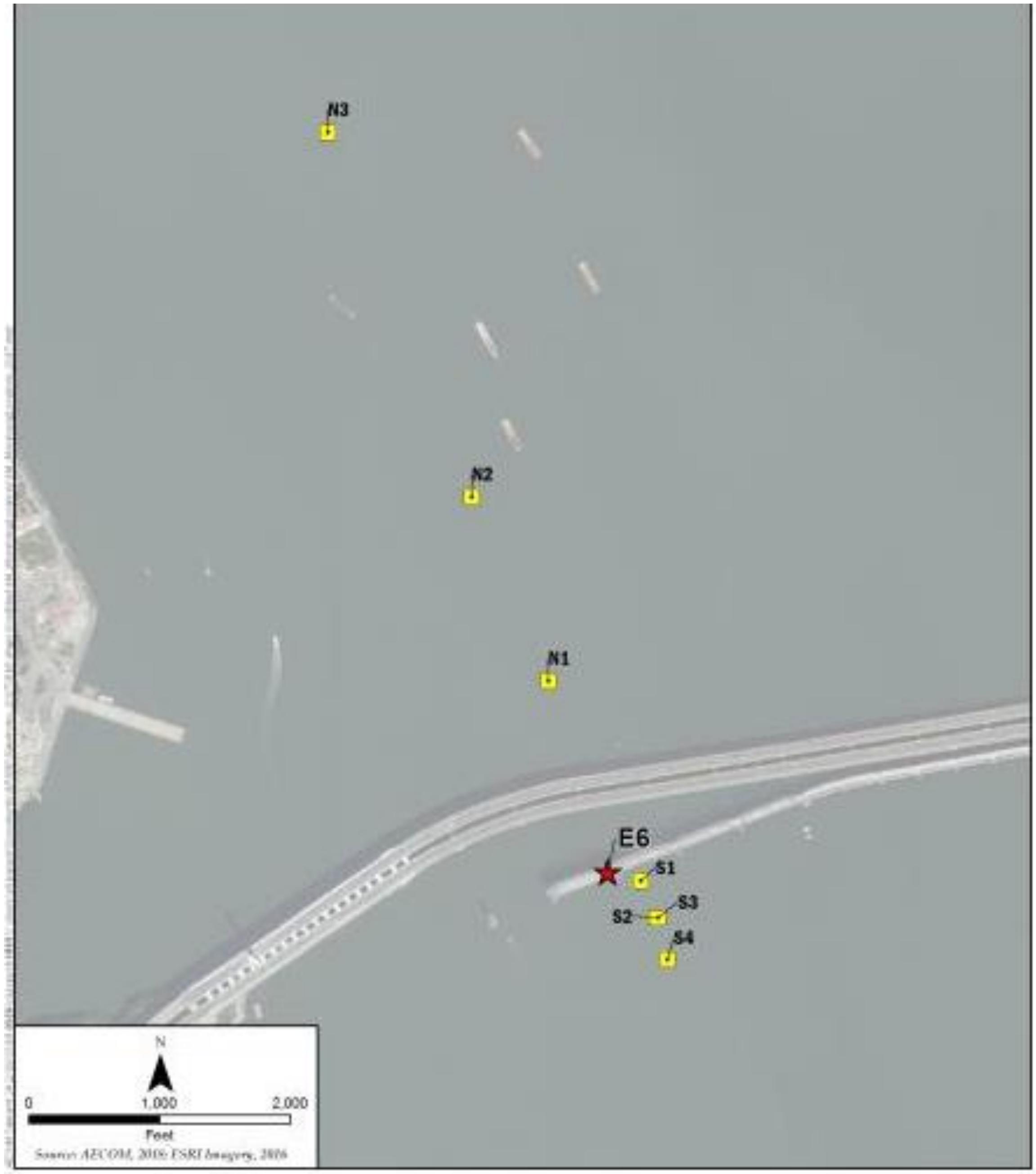

Figure 3-2. Deployed Near and Far-Field Locations where Data was Collected during the Implosion of Pier E6

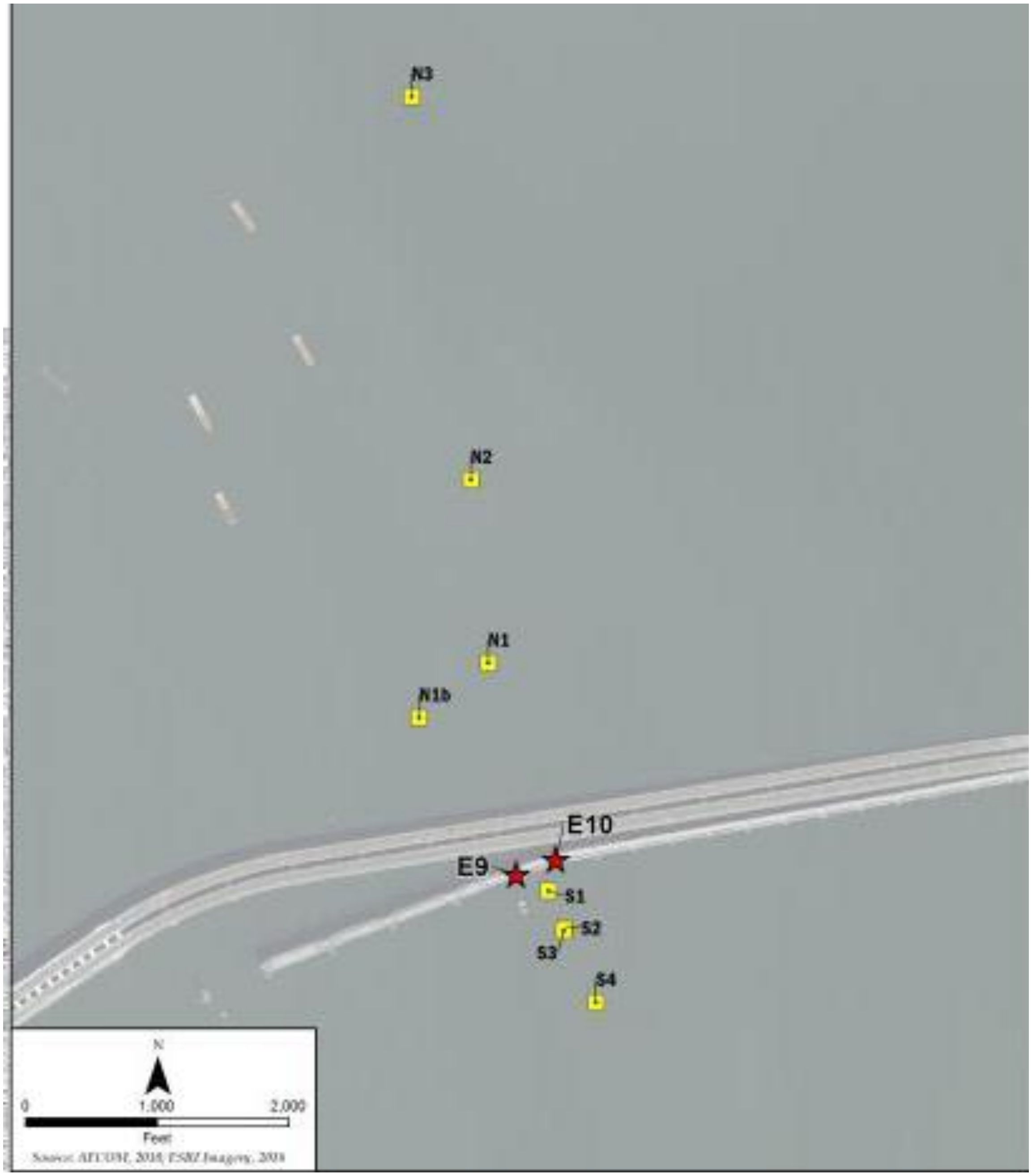

Figure 3-3. Deployed Near and Far-Field Locations where Data was Collected during the Implosion of Piers E9 and E10

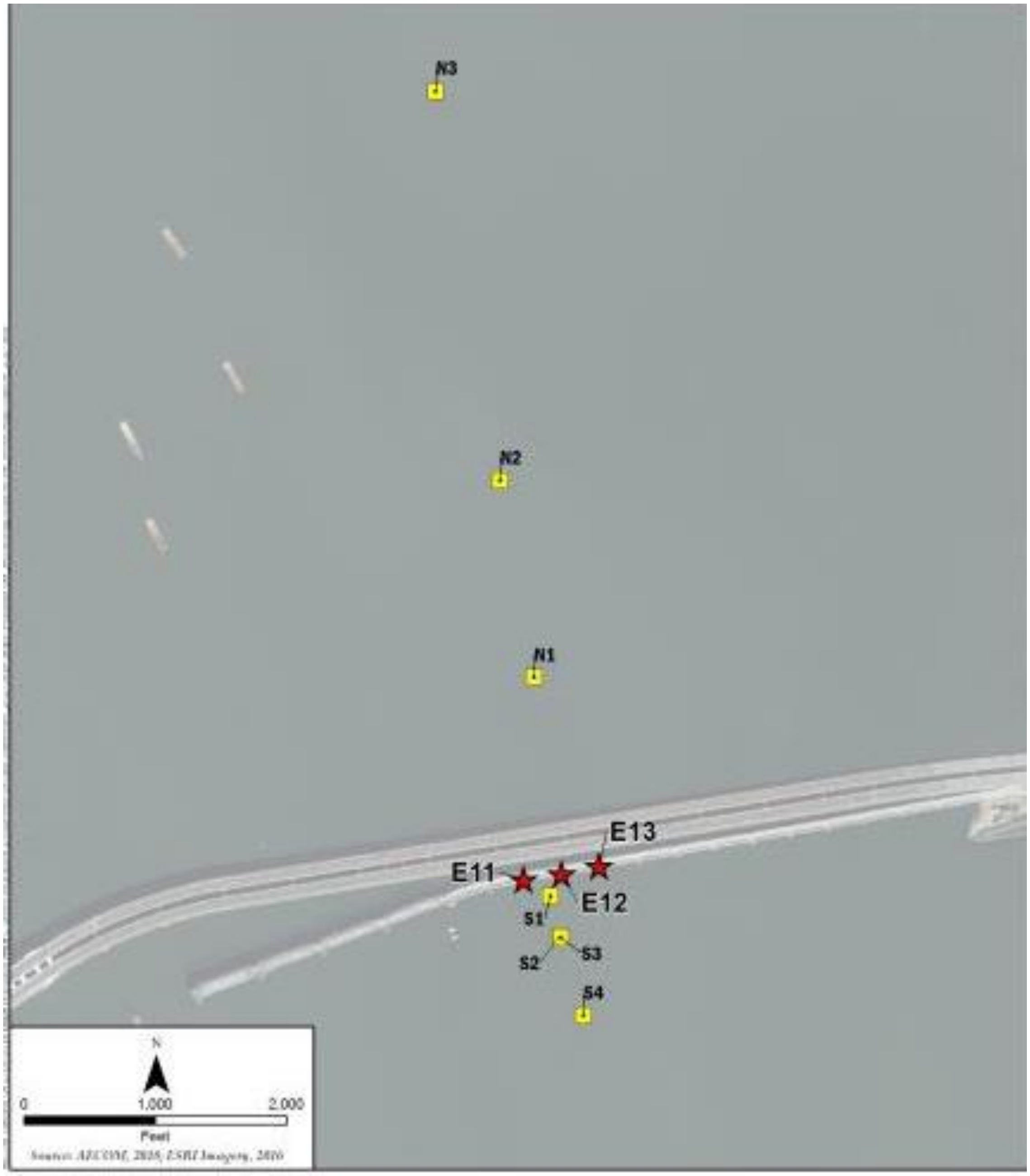

Figure 3-4. Deployed Near and Far-Field Locations where Data was Collected during the Implosion of Piers E11 to E13

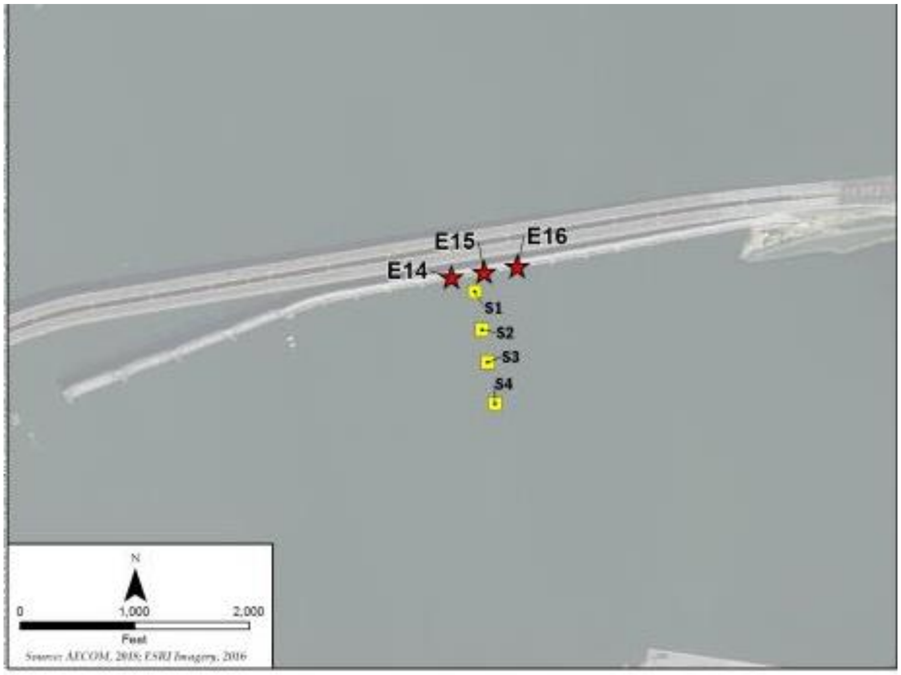

Figure 3-5. Deployed Near-Field Locations where Data was Collected during the Implosion of Piers E14 to E16

Figure 3-6. Deployed Near-Field Locations where Data was Collected during the Implosion of Piers E17 and E18

Table 3-3. Planned and Deployed Monitoring Locations for 2017 Implosion Events

		Location Name and Distance (in feet)							
		S1	**S2**	**S3**	**S4**	**N1**	**N1B**	**N2**	**N3**
Piers E7 & E8	**Planned Distance from Event (feet)**	200	500	800		1,500		3,000	6,000
	Deployed Distance from Event (feet)	216-E7 284-E8	477-E7 474-E8	806-E7 806-E8	N/A	1,482	N/A	3,046	6,035
	Usable Data Collected (Y/N)	Y	Y	Y		Y		Y	Y
Pier E6	**Planned Distance from Event (feet)**	200	500	500	800	1,500		3,000	6,000
	Deployed Distance from Event (feet)	198	457	447	762	1,525	N/A	3,019	6,021
	Usable Data Collected (Y/N)	Y	N	Y	Y	Y		Y	Y
Piers E9 & E10	**Planned Distance from Event (feet)**	200	500	500	1,100	1,500	1,500	3,000	6,000
	Deployed Distance from Event (feet)	237-E9 207-E10	522-E9 487-E10	535-E9 513-E10	1,132-E9 1,102-E10	1,579	1,431	2,966	5,911
	Usable Data Collected (Y/N)	Y	Y	Y	Y	Y	Y	Y	Y
Piers E11, E12 & E13	**Planned Distance from Event (feet)**	200	500	500	1,100	1,500		3,000	6,000
	Deployed Distance from Event (feet)	224-E11 178-E12 410-E13	487-E11 457-E12 584-E13	503-E11 473-E12 595-E13	1,123-E11 1,078-E12 1,114-E13	1,442	N/A	2,965	5,962
	Usable Data Collected (Y/N)	Y	N	Y	Y	Y		Y	Y
Piers E14 & E15	**Planned Distance from Event (feet)**	200	500	800	1,150				
	Deployed Distance from Event (feet)	219-E14 177-E15 419-E16	515-E14 496-E15 623-E16	788-E14 775-E15 860-E16	1,153-E14 1,147-E15 1,203-E16				
	Usable Data Collected (Y/N)	Y	Y	Y	Y	N/A			
Piers E16, E17 & E18	**Planned Distance from Event (feet)**	200	500	800	1,150				
	Deployed Distance from Event (feet)	220-E17 185-E18	520-E17 488-E18	798-E17 796-E18	1,158-E17 1,150-E18				
	Usable Data Collected (Y/N)	Y	Y	Y	Y				

3.1.5. **Establishing of Data Trend Lines**

For consistency in reporting results across all implosion events conducted in 2017, the curvatures of the trend lines (rate of level fall-off with distance) for each metric were determined using data points from all blast events that removed Piers E3 through E18. The trend line produced by all of the peak pressure levels is shown in Figure 3-7, and the trend line for the cSEL values is shown in Figure 3-8. These average trend lines were shifted vertically for the different implosion events, until the average difference between the trend line for a given event and near-field data points for that event was zero.

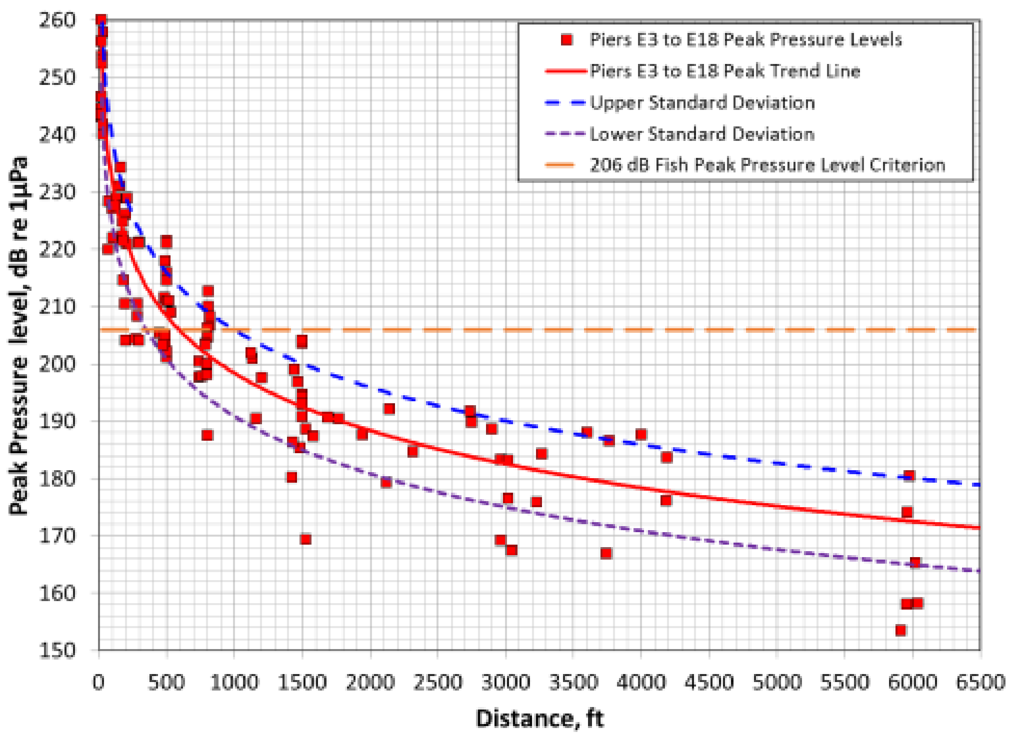

Figure 3-7. Peak Pressure Level Trend Line Produced in All Monitored Implosions

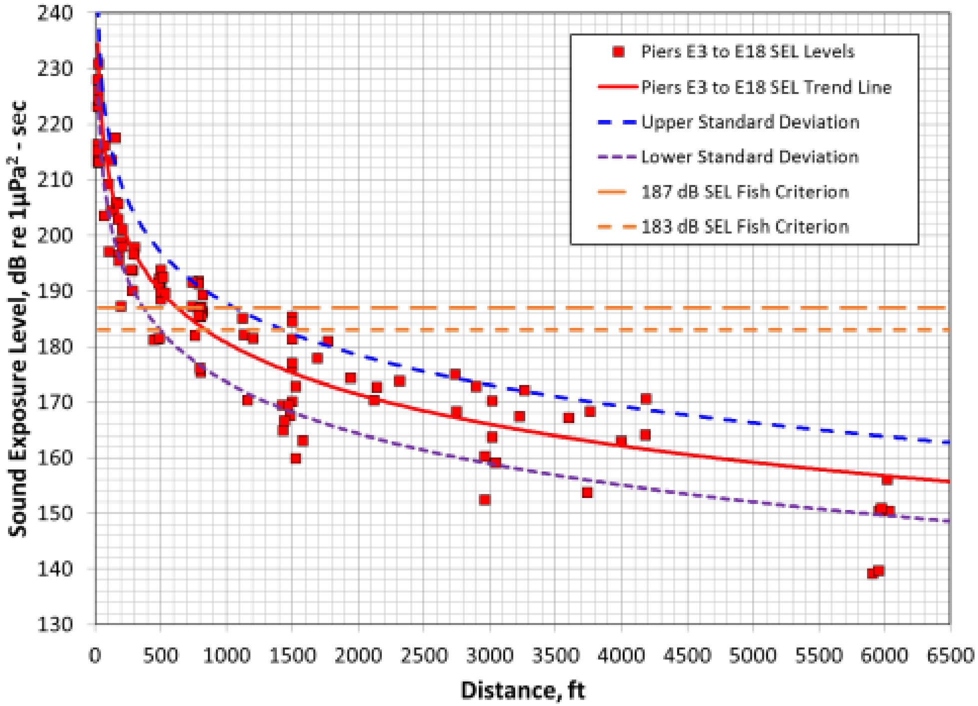

Figure 3-8. SEL Trend Line Produced in All Monitored Implosions

3.2. Monitoring Summary

3.2.1. Piers E7 and E8

Using the methods discussed above, the monitoring results captured during the Piers E7 and E8 blast event are shown in Table 3-4 for each location. The values include peak pressure in psi, peak sound pressure level in dB, cSEL in dB, and impulse pressure in psi-ms. The impulse metric is the summation of the energy in the greatest positive peak multiplied by the time resolution. This metric is used only to assess potential marine mammal lung injury and mortality.

Table 3-4. Hydroacoustic Monitoring Results for the Implosion of Piers E7 and E8

Location Name	Distance (feet)	Peak Pressure Level (pound per square inch)	Peak Sound Pressure Level (decibels)	cSEL (decibels)	Impulse (pounds per square inch-milliseconds)
S1	284a	3.81	208.4	190.1	1.53
S2	474a	2.14	203.4	181.3	0.90
S3	806a	0.35	187.5	175.3	0.14
N1	1,482	0.27	185.4	167.5	0.02
N2	3,046	0.03	167.5	159.1	0.08
N3	6,035	0.012	158.3	150.4	0.02

Note:

[a] The distance provided in the table and used for the plots reflects the distance from the sensor to the pier with the maximum peak level.

The peak sound pressure levels and the cSEL values for Piers E7 and E8 versus distance from the pier are shown in Figure 3-9. In addition, the 206 dB peak sound pressure threshold and the 187 and 183 dB cSEL thresholds for fish injury also are shown.

For Piers E7 and E8, the results show a small amount of scatter about the peak and cSEL trend lines. The scatter of the cSEL data points about the trend line is substantially less than for the peak data points. Within 1,500 feet (457 meters), the peak measurement points lie above the trend line, while at distances beyond 3,000 feet (914 meters), the points lie more than 3 dB below the trend line (Figure 3-9).

The Piers E7 and E8 impulse levels and the marine mammal criteria for lung injury and mortality for the most sensitive marine mammal species, northern fur seal, are shown in Figure 3-10. The trend line for the impulse level has a faster fall-off rate than the impulse trend lines for Piers E3, E4, and E5, and the trend line falls below 0 dB within 700 feet (213 meters).

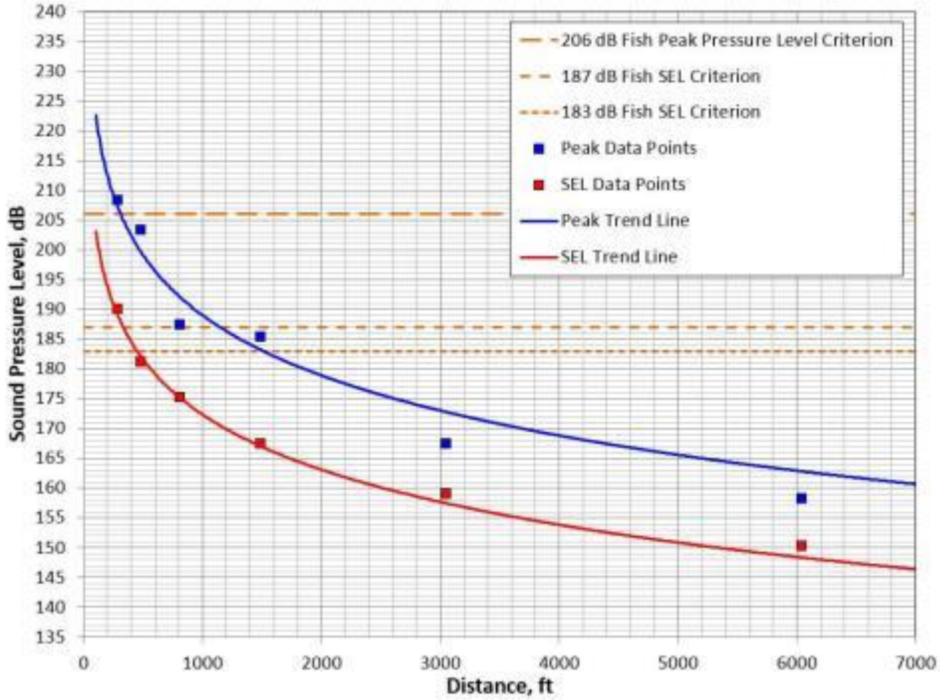

Figure 3-9. Piers E7 and E8 Peak Sound Pressure Levels and cSEL Values

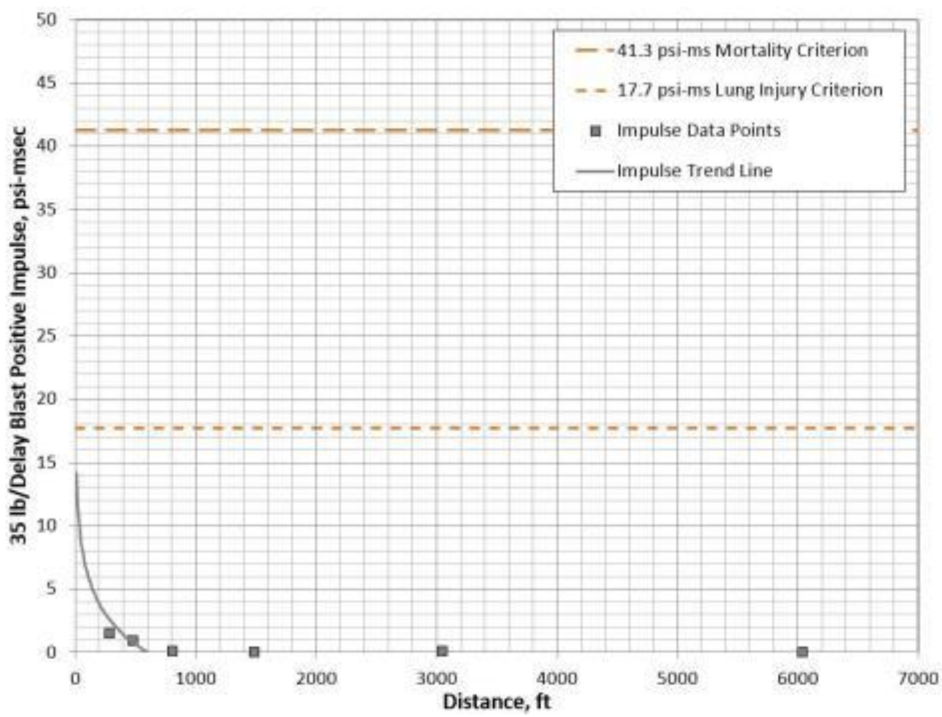

Figure 3-10. Piers E7 and E8 Impulse Values

The time histories for the sound pressure levels at each of the near-field measurement locations are shown in Figures 3-11, 3-12, and 3-13. At 284 feet (86.5 meters) south (S1) and 474 feet (144 meters) south (S2), the peak pressures occurred at the beginning of the implosion of Pier E8 and the relative peak pressures throughout the implosion of Pier E7 were consistent and lower than Pier E8 throughout the blast event (Figure 3-11). The double-headed arrows indicate the actual times when implosion occurred and signals after the last arrow (~4,500 ms) are not because of the detonations. At 806 feet (245 meters) south (S3), peak pressures of nearly equivalent amplitude were measured at the beginning of each pier implosion (Figure 3-12). A considerable difference occurs in the sound level time histories between the north and south measurement lines.

The far-field time histories are shown in Figures 3-14 through 3-16, and unlike the near-field results to the south, they show higher levels during the Pier E7 implosion than that of Pier E8. The results at 1,482 feet (451 meters) north (N1) and 3,046 feet (928 meters) north (N2) of the blast event show higher sound pressure levels during the Pier E7 implosion compared to the Pier E8 implosion throughout the blast event (Figures 3-14 and 3-15). Levels at 6,035 feet (1,839 meters) north (N3) were relatively consistent throughout the duration of both pier implosions (Figure 3-16). These results may have been affected by an existing pier of the SFOBB new east span that blocked the line of sight from the monitoring stations to Pier E8. This condition may have provided shielding of the Pier E8 implosion event at the closer far-field positions (N1 and N2).

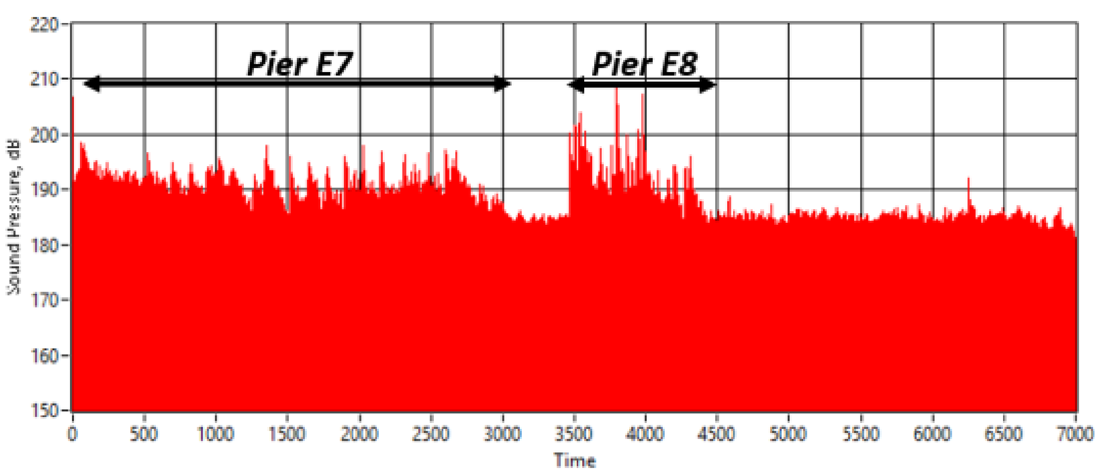

Figure 3-11. Sound Pressure Time History for Piers E7 and E8 at S1 (284 feet)

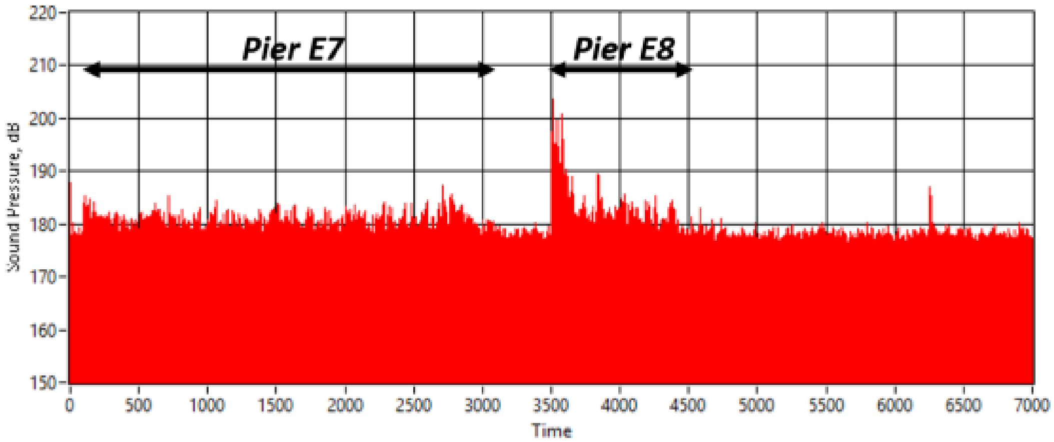

Figure 3-12. Sound Pressure Time History for Piers E7 and E8 at S2 (474 feet)

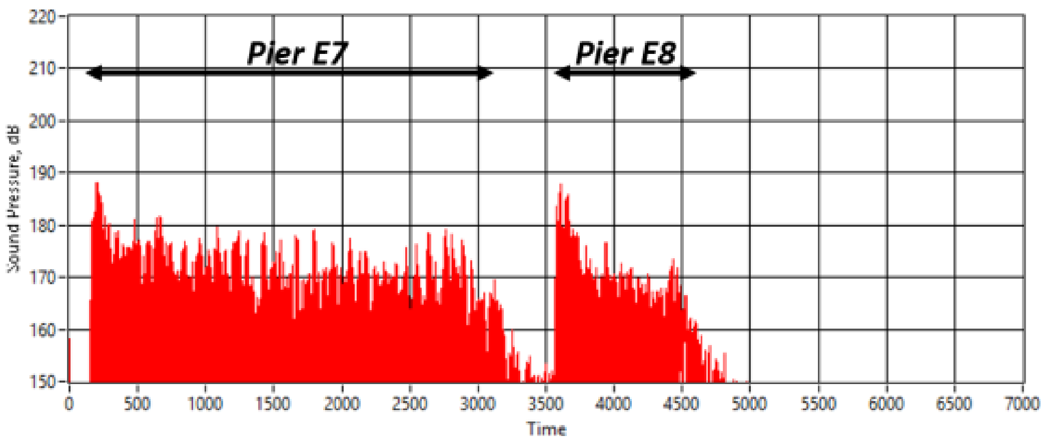

Figure 3-13. Sound Pressure Time History for Piers E7 and E8 at S3 (806 feet)

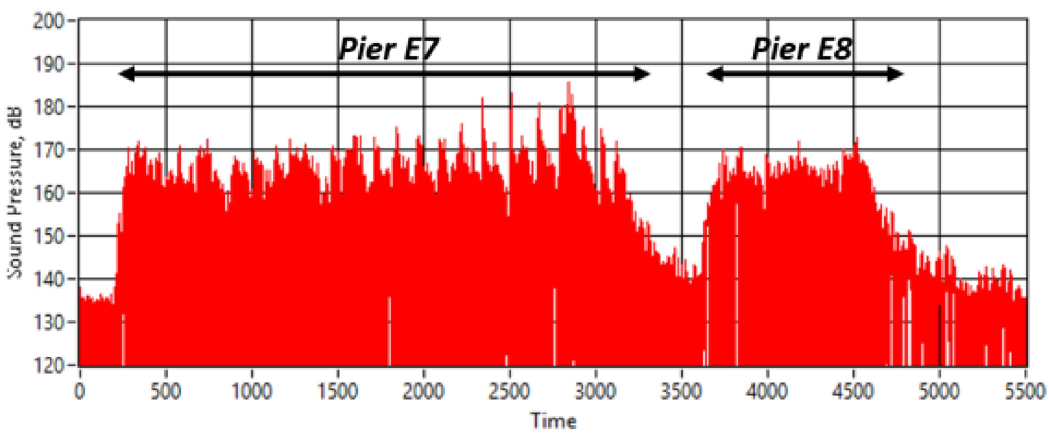

Figure 3-14. Sound Pressure Time History for Piers E7 and E8 at N1 (1,482 feet)

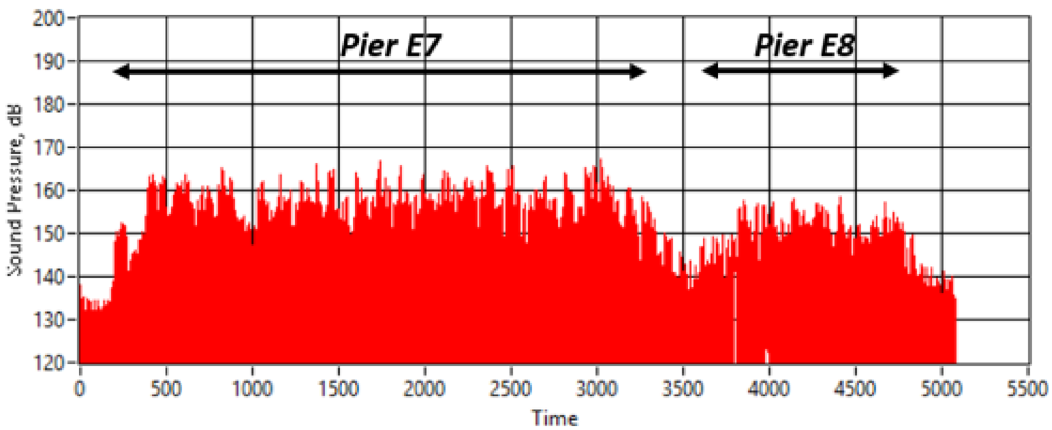

Figure 3-15. Sound Pressure Time History for Piers E7 and E8 at N2 (3,046 feet)

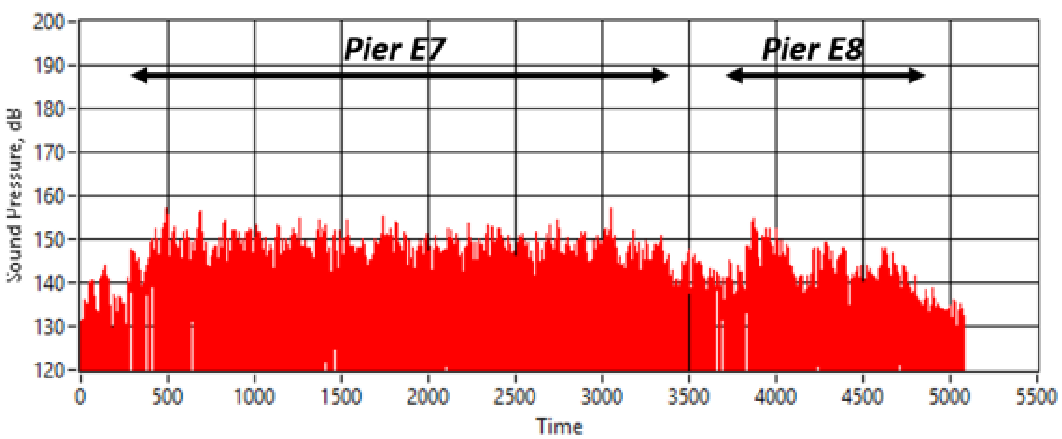

Figure 3-16. Sound Pressure Time History for Piers E7 and E8 at N3 (6,035 feet)

The sound pressure levels and cSEL levels at each of the far-field locations are shown in Figures 3-17 through 3-19. Including the 500 ms delay between the implosion of each pier, the total duration of the implosion event was about 4,350 ms, which starts at about 500 ms and ends at about 4,850 ms, as shown in Figure 3-17. The cSEL in this figure rises gradually until reaching the peak pressure, which occurs at about 3,000 ms. At the point where the peak pressure occurs, a relatively fast increase in cSEL is noted. After the peak pressure, the cSEL increases gradually by about 1 dB through the remaining blast event, which includes the entire Pier E8 implosion. As measurement distances become greater, the sudden increase in cSEL occurs at the time when the peak pressure level becomes less pronounced (Figure 3-18). At 6,035 feet (1,839 meters) north (N3), this phenomenon is not observable and the cSEL shows a gradual increase throughout the entire blast event (Figure 3-19).

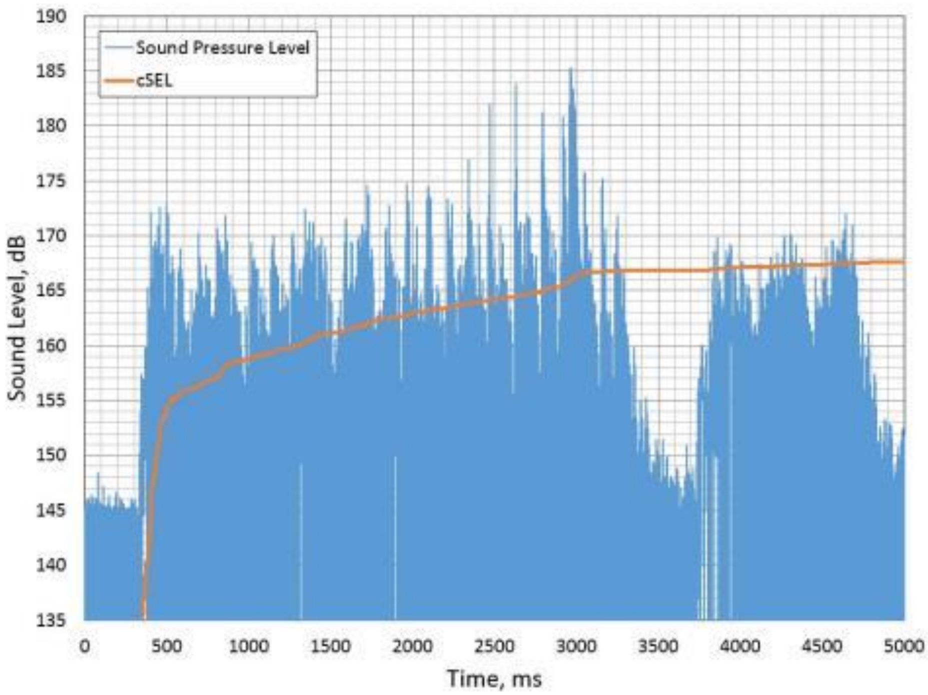

Figure 3-17. Sound Pressure Time History of Peak Sound Pressure Level and cSEL for Piers E7 and E8 at 1,482 feet (N1)

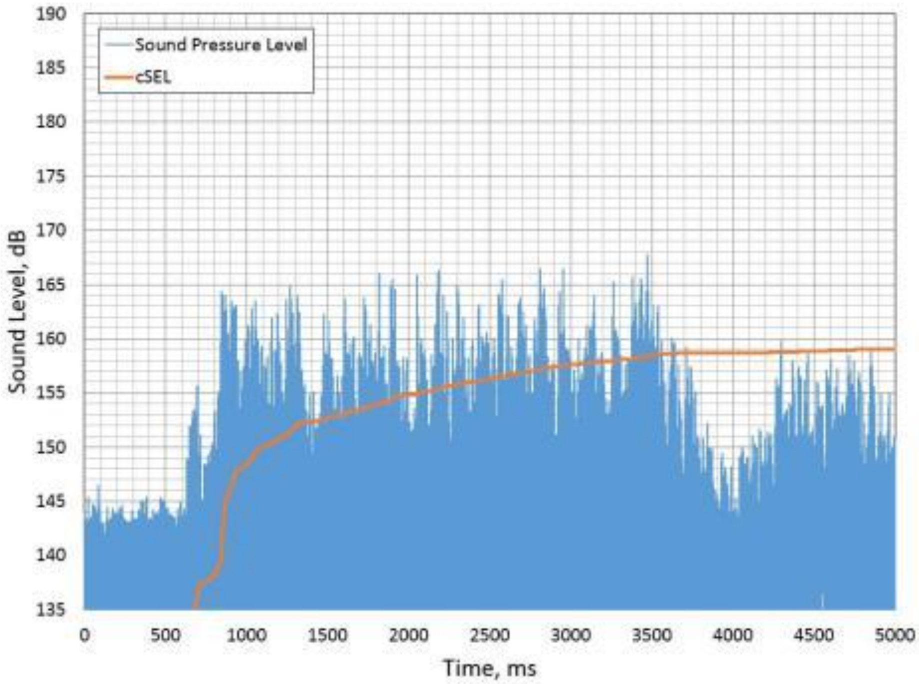

Figure 3-18. Sound Pressure Time History of Peak Sound Pressure Level and cSEL for Piers E7 and E8 at 3,046 feet (N2)

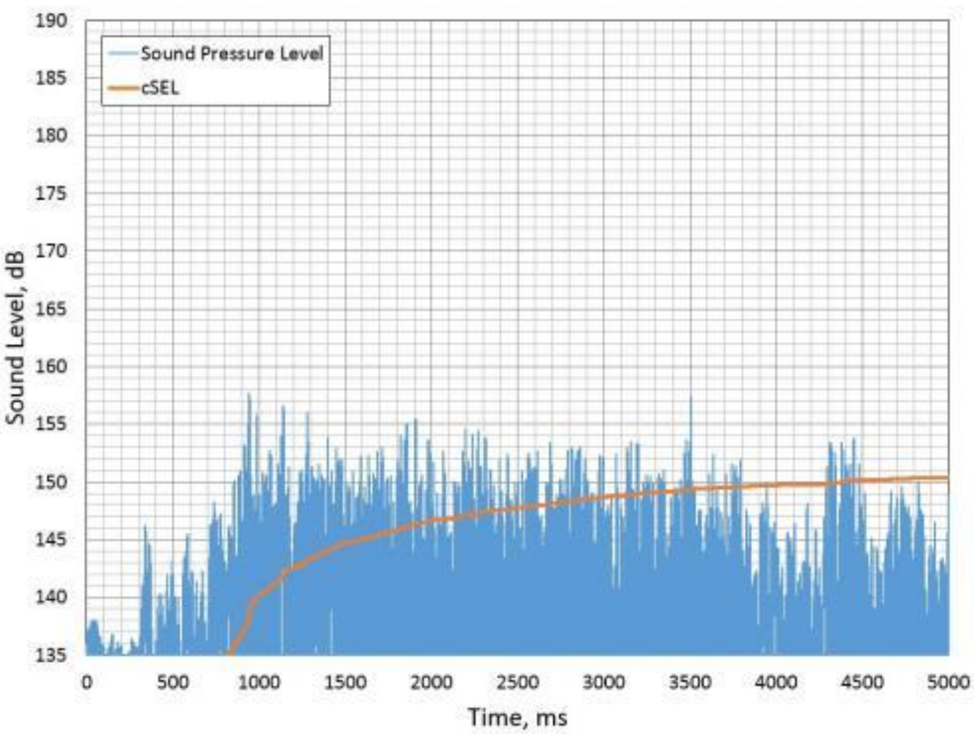

Figure 3-19. Sound Pressure Time History of Peak Sound Pressure Level and cSEL for Piers E7 and E8 at 6,035 feet (N3)

3.2.2. Pier E6

The monitoring results taken during the implosion of Pier E6 are shown in Table 3-5 for each location. The values include peak pressure in psi, peak sound pressure level in dB, cSEL in dB, and impulse pressure in psi-ms. For this event, the measurement at 457 feet (139 meters) south (S2) using a PCB pressure transducer was discounted, and the reported values at the adjacent 447 feet (136 meters) south (S3), obtained with a Reson hydrophone, were used for analysis because of the reduced instrument noise in this data set. The peak sound pressure levels and cSEL values for Pier E6 versus distance from the pier are shown in Figure 3-20. The fish injury criteria also are shown.

The differences between the cSEL trend line and the measured values for Pier E6 are substantially greater than the peak (Figure 4-23). At the near-field location of 762 feet (232 meters) south (S4), the cSEL value is about 7 dB greater than the trend line and consistently increases to about 8 dB just beyond 6,000 feet (1,828 meters) (Figure 3-20). The peak pressure levels also are greater than the trend line beyond 400 feet (121 meters); however, the differences range from only 2 to 5 dB. The reasons for this apparent anomaly could not be determined. However, some unique behaviors are indicated by the near-field levels. For the peak pressure, the levels at 447 feet (136 meters) south (S3) are slightly greater than at 198 feet (60 meters) south (S1), by about 1 dB. For cSEL, the level at 762 feet (232 meters) south (S4) is about 1 dB greater than the closer level at 447 feet (136 meters) south (S3).

Table 3-5. Hydroacoustic Monitoring Results for the Implosion of Pier E6

Location Name	Distance (feet)	Peak Pressure Level (pound per square inch)	Peak Sound Pressure Level (decibels)	cSEL (decibels)	Impulse (pounds per square inch-milliseconds)
S1	198	2.35	204.2	187.2	1.70
S3	447	2.72	205.5	181.2	1.88
S4	762	1.14	197.9	182.0	1.18
N1	1,525	0.39	188.7	172.8	0.37
N2	3,019	0.10	176.5	163.7	0.11
N3	6,021	0.03	165.3	156.0	0.04

Note:

[a] The distance provided in the table and used for the plots reflects the distance from the sensor to the pier with the maximum peak level.

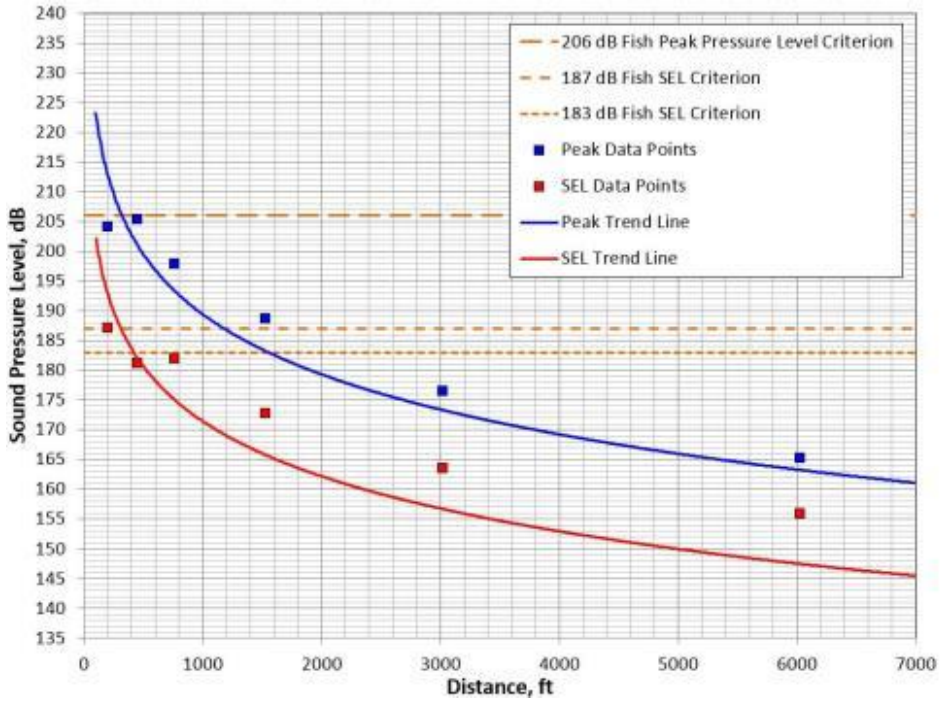

Figure 3-20. Pier E6 Peak Sound Pressure Levels and cSEL Values

The impulse levels measured during the Pier E6 implosion, as well as the trend line and the marine mammal criteria, are shown in Figure 3-21. The trend line crosses zero just after 600 feet (182 meters).

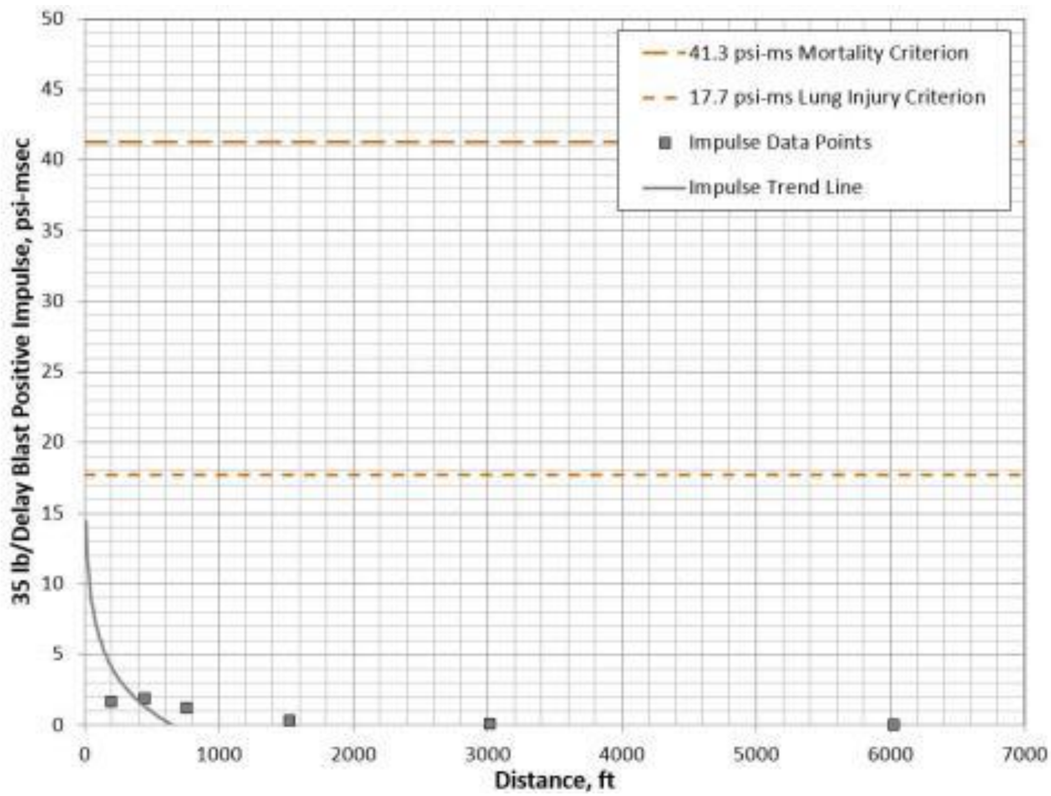

Figure 3-21. Pier E6 Impulse Levels

The time histories for the sound pressure levels at each of the near-field measurement locations are shown in Figures 3-22, 3-23, and 3-24, and the time histories for each of the far-field locations are shown in Figures 3-25, 3-26, and 3-27. Each of the near-field measurements show that the maximum peak pressure occurred within 100 ms after the blast initiation, while the far-field results show that the peak pressure occurred towards the end of the implosion. At 1,525 feet (464 meters) north (N1), the peak levels increase by almost 15 dB from the start of the implosion to the end (Figure 3-25). The differences between the near and far-field trends likely are because of the orientation of the monitoring arrays to the pier as related to the progression of the individual blasts through the structure, which began on the south end of the pier and finished at the north end. For the more distant far-field results, the levels differ by lesser amounts: by 10 dB at 3,019 feet (920 meters) north (N2) and 5 dB at 6,071 feet (1,850 meters) north (N3) from the beginning to the end. These differences in amplitude trends between the south and north line measurements may have contributed to the differences that are noted in Figure 3-20.

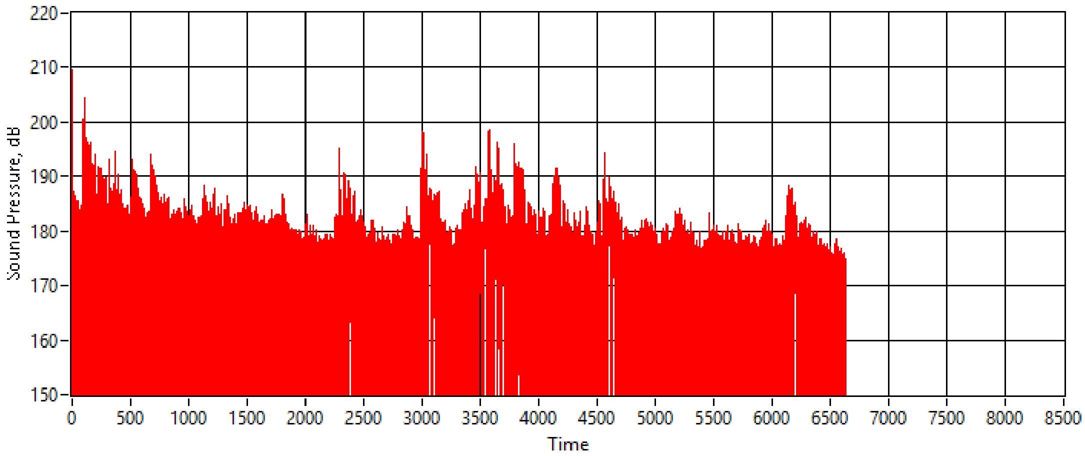

Figure 3-22. Sound Pressure Time History for Pier E6 at S1 (198 feet)

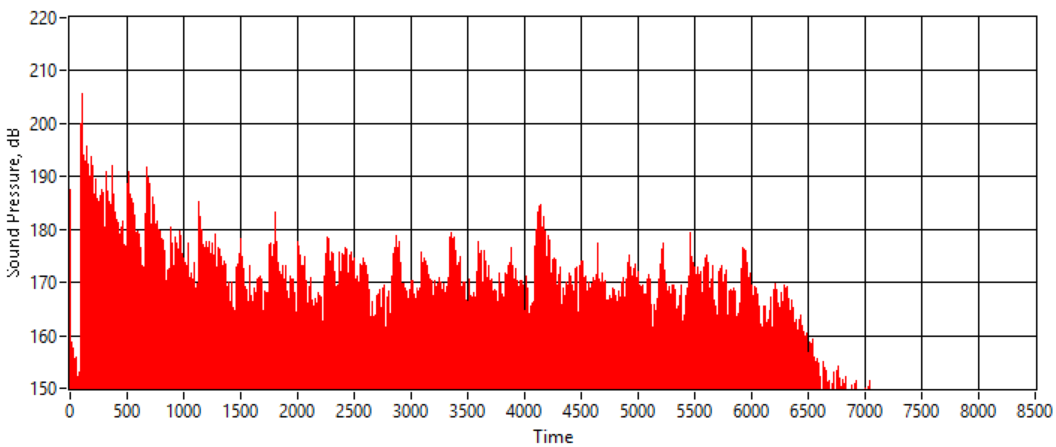

Figure 3-23. Sound Pressure Time History for Pier E6 at S3 (447 feet)

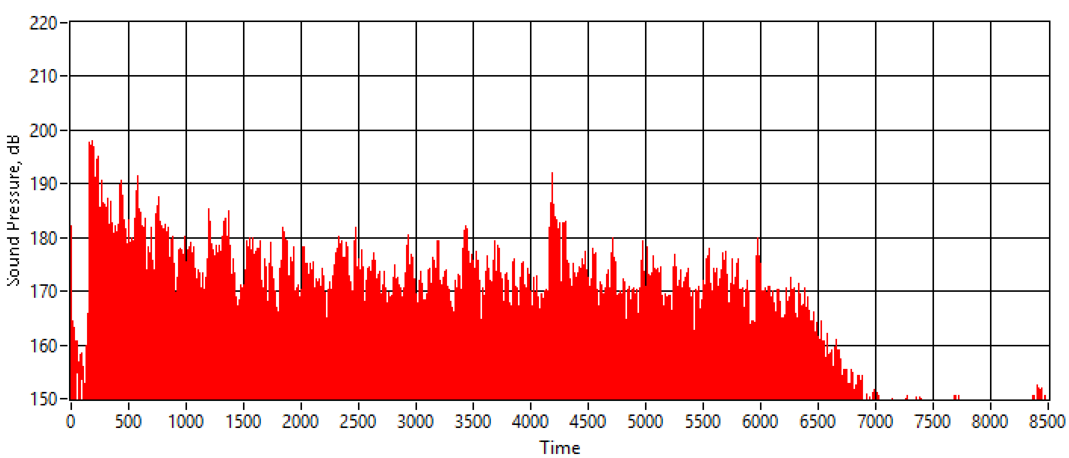

Figure 3-24. Sound Pressure Time History for Pier E6 at S4 (762 feet)

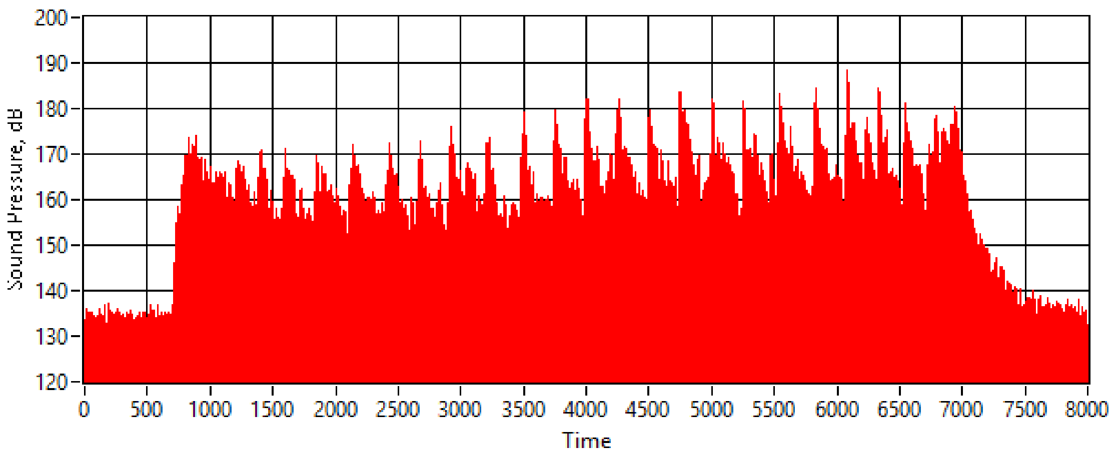

Figure 3-25. Sound Pressure Time History for Pier E6 at N1 (1,525 feet)

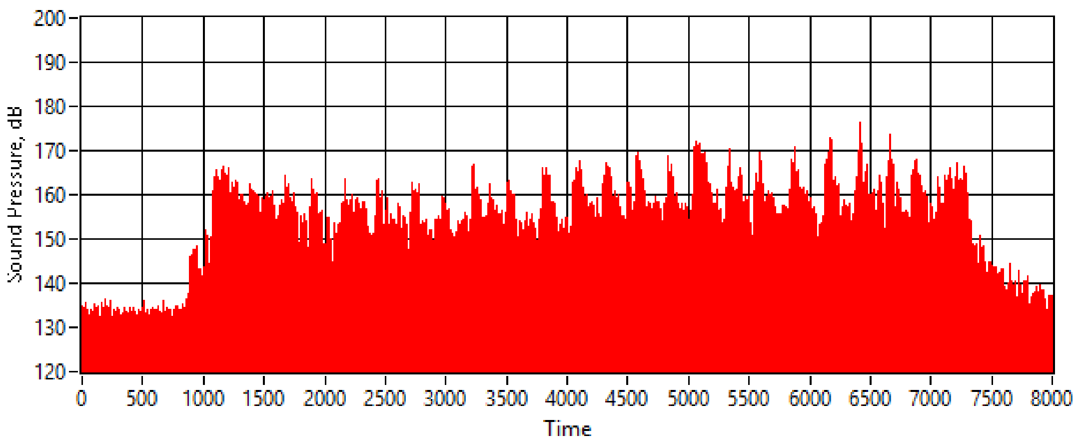

Figure 3-26. Sound Pressure Time History for Pier E6 at N2 (3,019 feet)

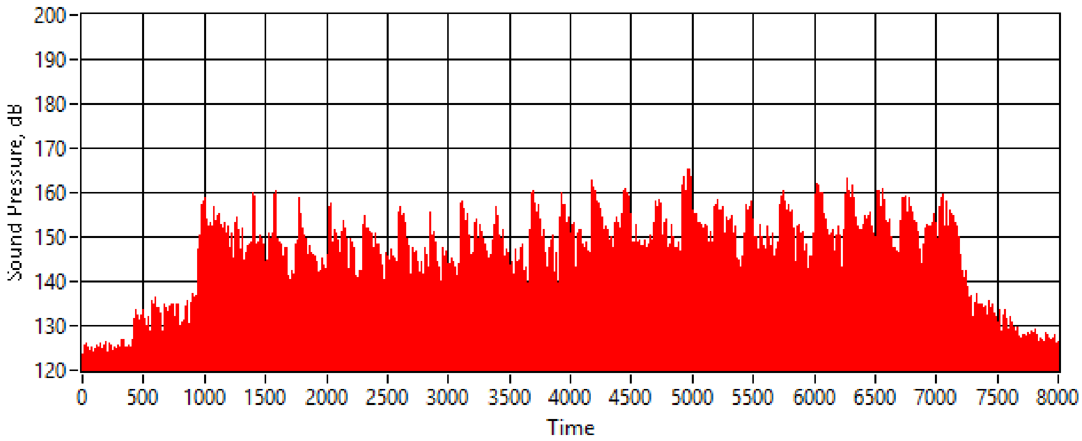

Figure 3-27. Sound Pressure Time History for Pier E6 at N3 (6,071 feet)

The sound pressure levels and cSEL levels at each of the far-field locations are shown in Figures 3-28 through 3-30. The total time of the implosion event was about 5,700 ms, which started at about 1,000 ms and ended at about 7,150 ms (Figure 3-26). The cSEL in this figure rises gradually throughout the signal.

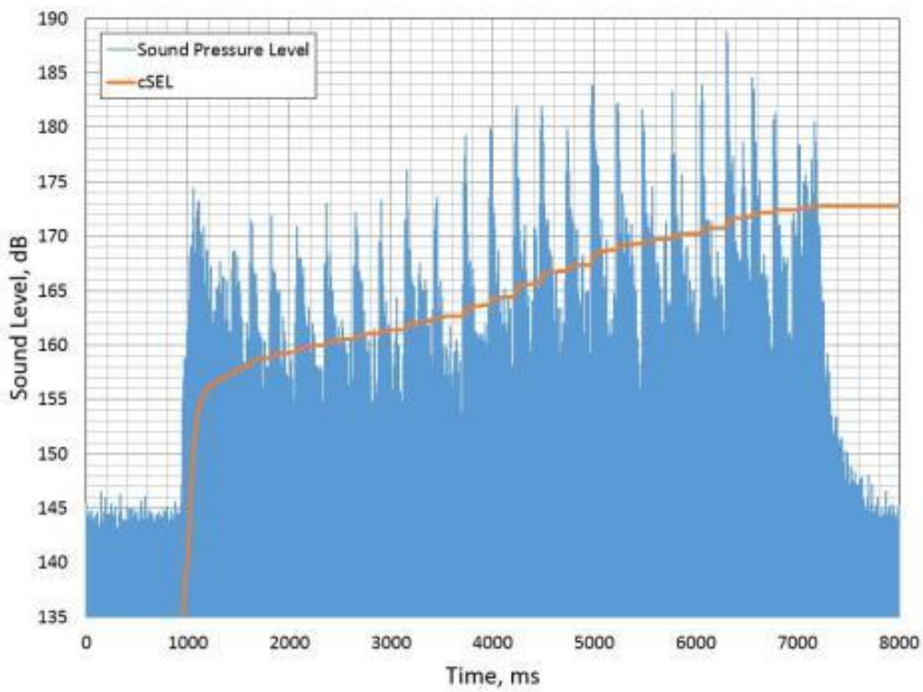

Figure 3-28. Sound Pressure Time History of Peak Sound Pressure Level and cSEL for Pier E6 at 1,525 feet (N1)

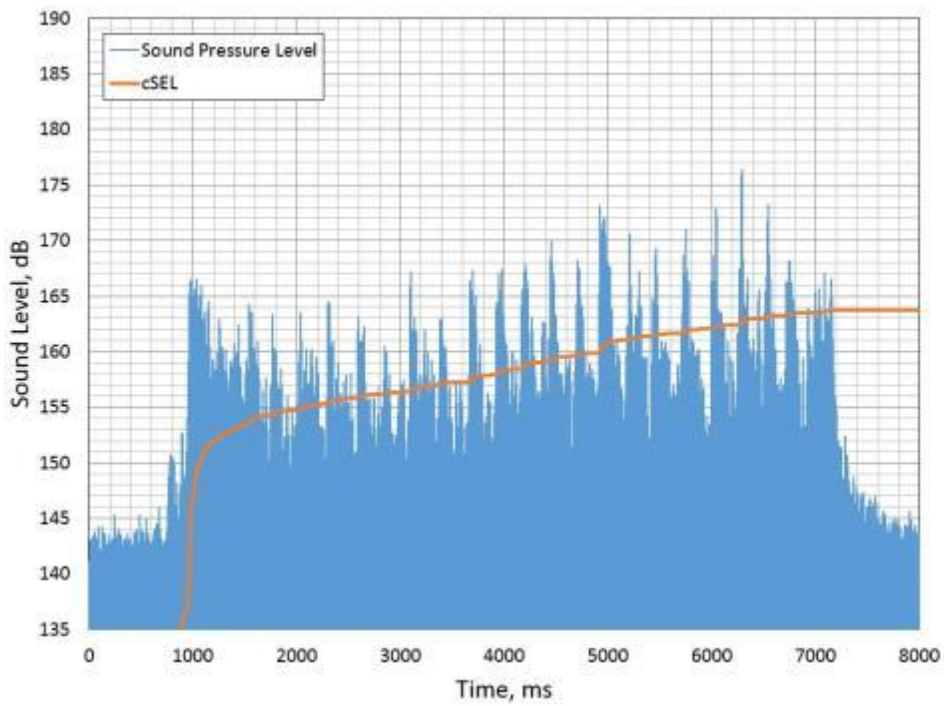

Figure 3-29. Sound Pressure Time History of Peak Sound Pressure Level and cSEL for Pier E6 at 3,019 feet (N2)

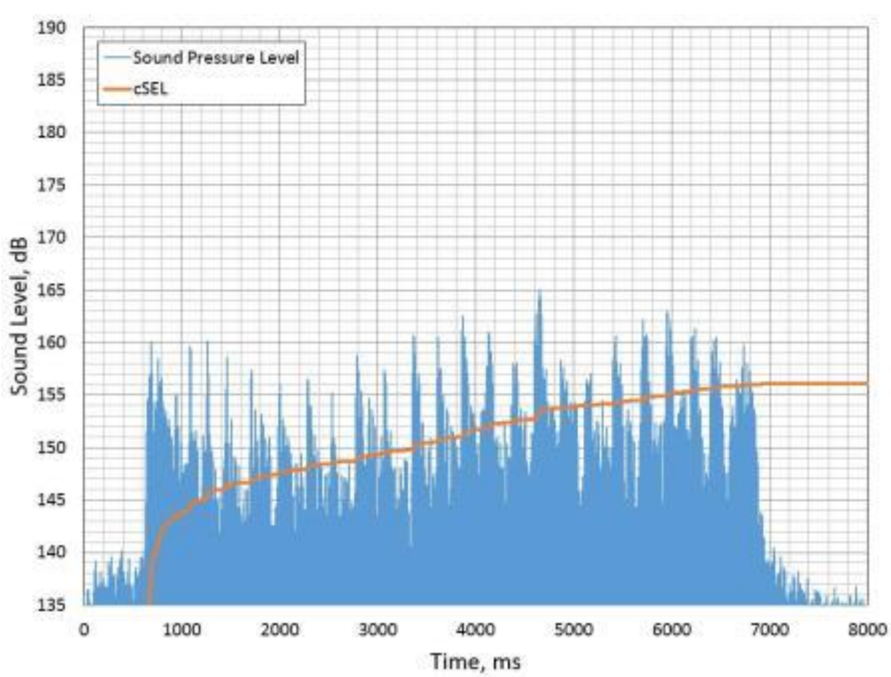

Figure 3-30. Sound Pressure Time History of Peak Sound Pressure Level and cSEL for Pier E6 at 6,021 feet (N3)

3.2.3. Piers E9 and E10

The monitoring results captured during the Piers E9 and E10 blast event are shown in Table 3-6 for each location. The values include peak pressure in psi, peak sound pressure level in dB, cSEL in dB, and impulse pressure in psi-ms.

The peak sound pressure levels and cSEL values for Piers E9 and E10 versus distance from the pier are shown in Figure 3-31, with the trend lines and fish criteria. The measured results for Piers E9 and E10 in the far field fall below the trendlines for both the peak and SEL values. At 5,911 feet (1,801 meters), the peak level is more than 20 dB below the trend line at that point, while the cSEL value is about 18 dB below the trend line.

The impulse trend line shown in Figure 3-32 does not cross zero until about 900 feet (274 meters).

Table 3-6. Hydroacoustic Monitoring Results for the Implosion of Piers E9 and E10

Location Name	Distance (feet)	Peak Pressure Level (pound per square inch)	Peak Sound Pressure Level (decibels)	cSEL (decibels)	Impulse (pounds per square inch-milliseconds)
S1	207[a]	16.32	221.0	198.0	5.27
S2	487[a]	5.49	211.6	191.5	2.04
S3	535[a]	4.10	209.0	189.6	1.25
S4	1,132[a]	1.63	201.0	182.1	0.60
N1	1,579	0.34	187.4	163.0	0.02
N1B	1,431	0.30	186.4	164.9	0.01
N2	2,966	0.04	169.2	152.5	<0.00
N3	5,911	0.01	153.5	139.2	<0.00

Note:

[a] The distance provided in the table and used for the plots reflects the distance from the sensor to the pier with the maximum peak level.

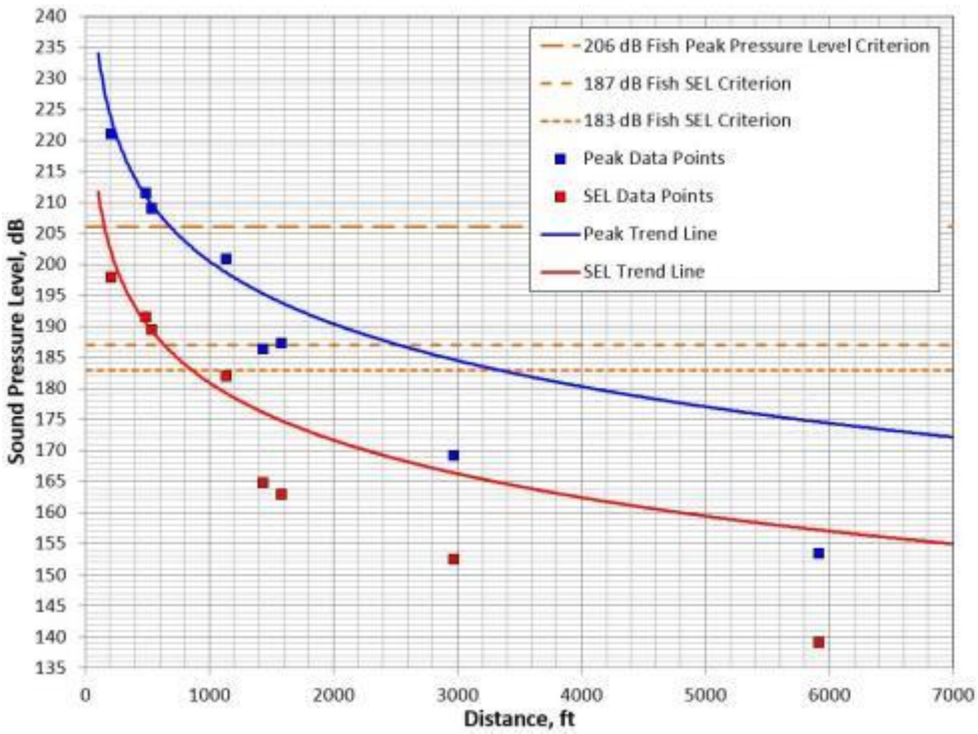

Figure 3-31. Piers E9 and E10 Peak Sound Pressure Levels and cSEL Values

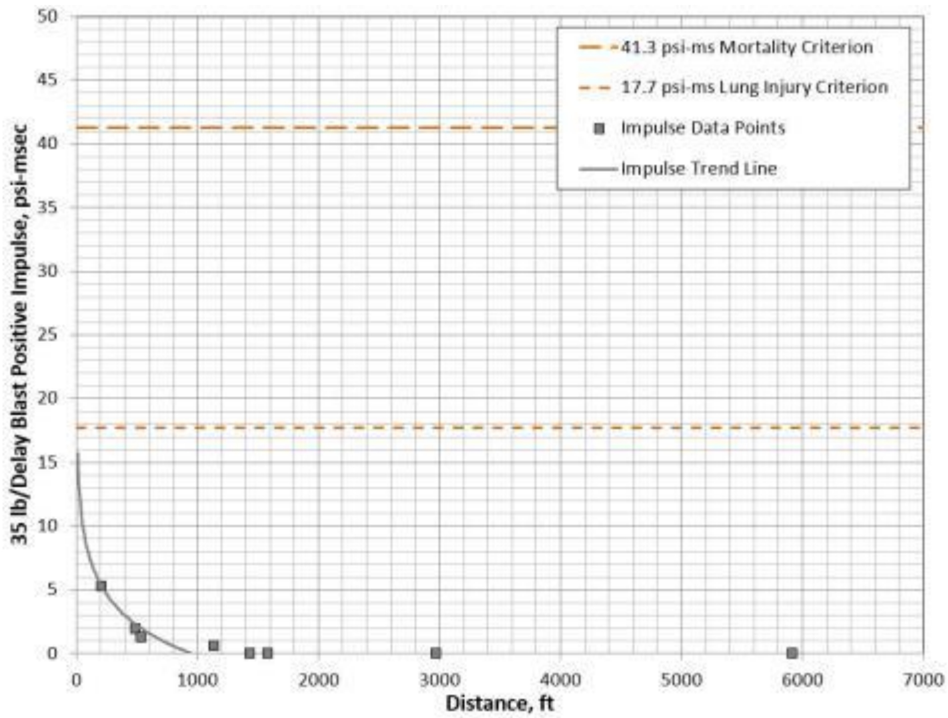

Figure 3-32. Piers E9 and E10 Impulse Levels

The time histories for the sound pressure levels at each of the near-field measurement locations are shown in Figures 3-33 through 3-36. At each of the near-field measurement locations, relative peaks before the 2,000 ms mark typically were 10 to 12 dB lower than those after 2,000 ms. The Pier E9 structure had a unique design, compared to the other SFOBB original east span piers, and the blast plan was designed so that the inner walls were detonated first, followed by the outer walls. Therefore, the pressures generated by earlier individual detonations were shielded somewhat by the outer walls, resulting in lower observed levels at the near-field monitoring locations during the early portion of the Pier E9 implosion. For Pier E10, the blast plan sequence was similar to that used for all of the other piers, with the blasts progressing from south to north. This resulted in the peak pressures decreasing with time for the Pier E10 near-field levels up to the end of the sequence at about 4,000 ms. The maximum charge weight used for Piers E9 and E10 was the same, accounting for the peaks at the end for Pier E9 and those at the beginning for Pier E10 being similar in level.

The far-field time histories indicate a substantially different trend than the near-field time histories, as shown in Figures 3-37 through 3-40. For these data, the implosion of Pier E10 resulted in levels that were 15 to 20 dB lower than Pier E9 for the closer N1 and N1B monitoring locations (Figures 3-37 and 3-38). The further out locations of N2 and

N3 indicated this behavior also, except that the difference between Piers E9 and E10 were smaller, about 10 dB (Figures 4-42 and 3-40). As noted above, the maximum charge weights were the same for the two piers, with the peak levels expected to be more similar for Piers E9 and E10. At the far-field monitoring locations, Pier E9 may have been partially shielded by the SFOBB new east span's piers. This may account some of the differences between the Piers E9 and E10 implosions, as measured to the north compared to the unshielded locations to the south.

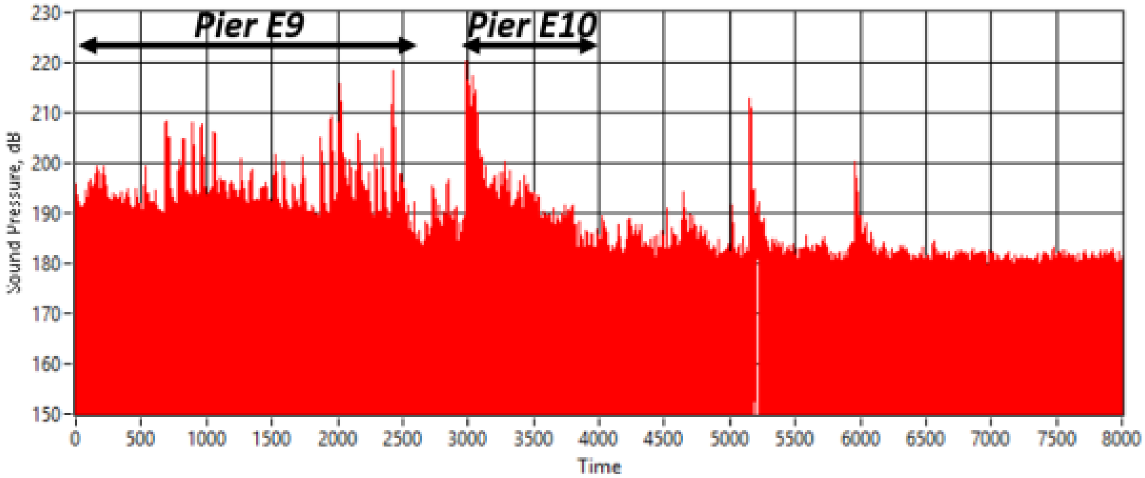

Figure 3-33. Sound Pressure Time History for Piers E9 and E10 at S1 (207 feet)

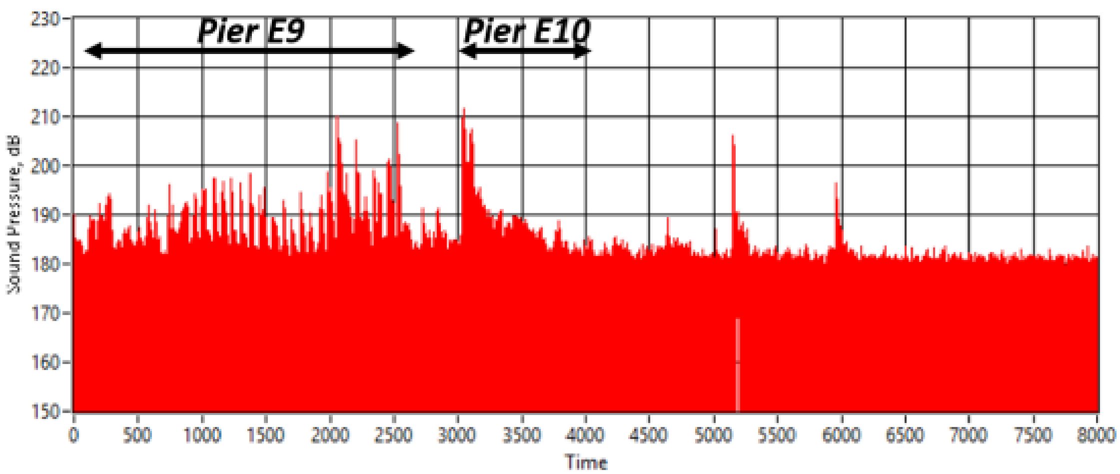

Figure 3-34. Sound Pressure Time History for Piers E9 and E10 at S2 (487 feet)

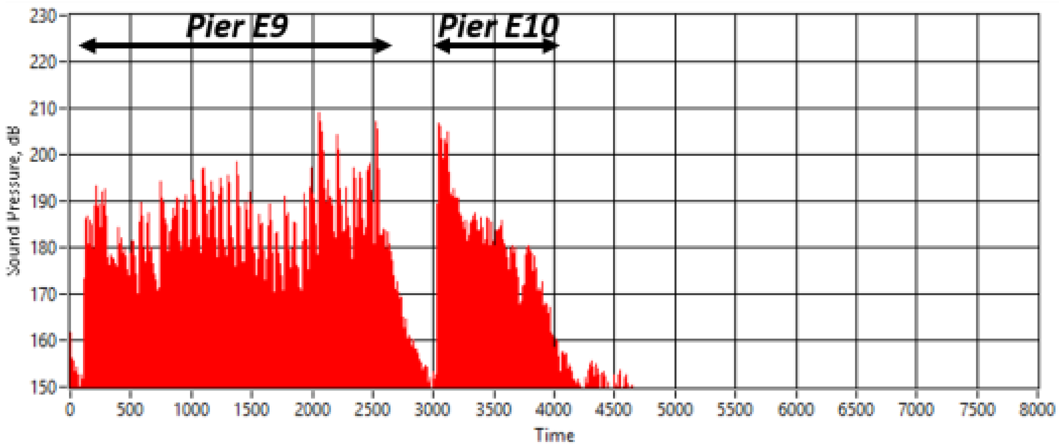

Figure 3-35. Sound Pressure Time History for Piers E9 and E10 S3 (535 feet)

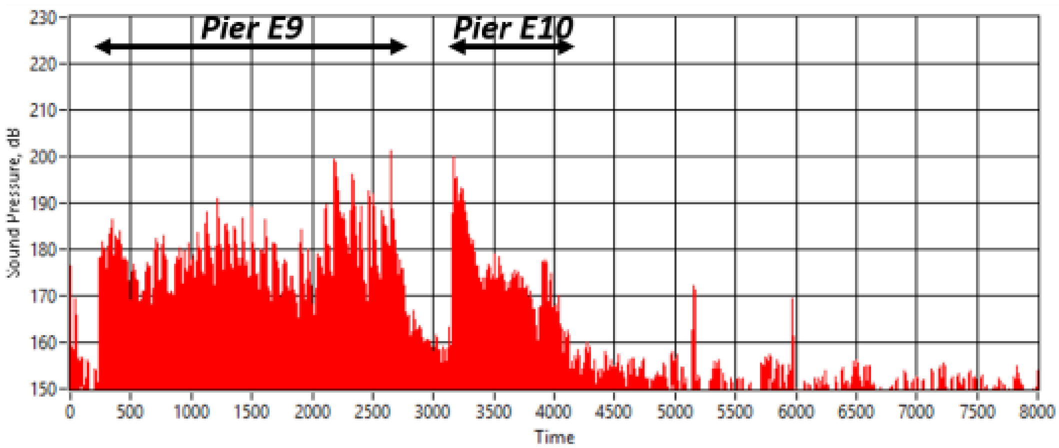

Figure 3-36. Sound Pressure Time History for Piers E9 and E10 at S4 (1,132 feet)

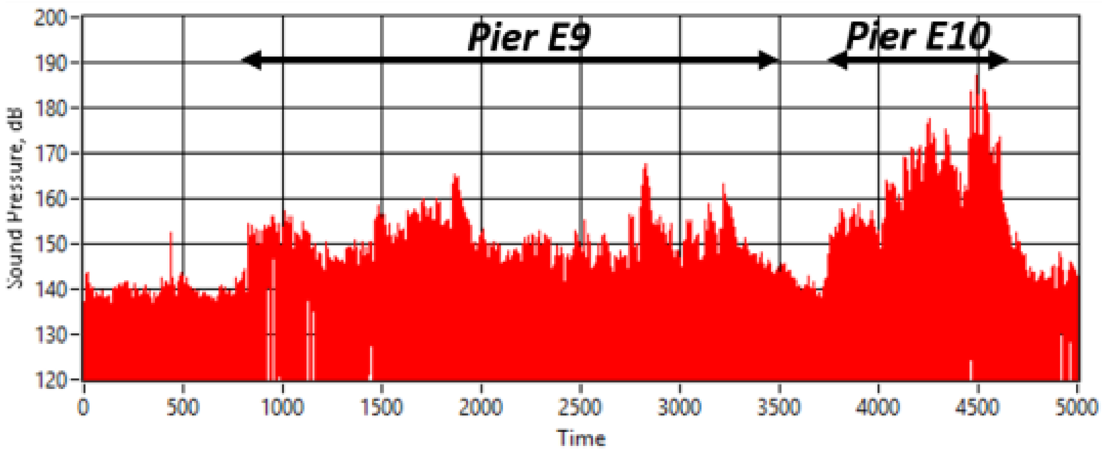

Figure 3-37. Sound Pressure Time History for Piers E9 and E10 at N1 (1,579 feet)

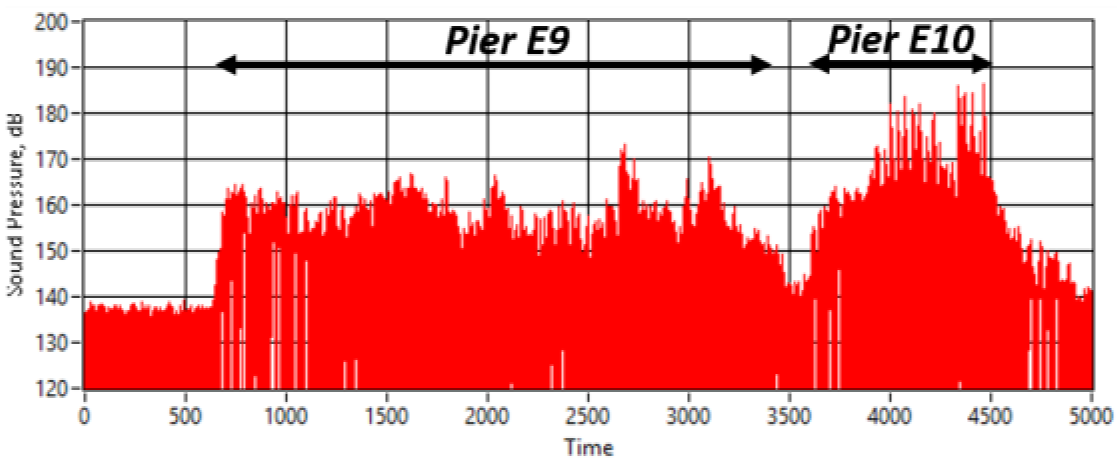

Figure 3-38. Sound Pressure Time History for Piers E9 and E10 at N1B (1,431 feet)

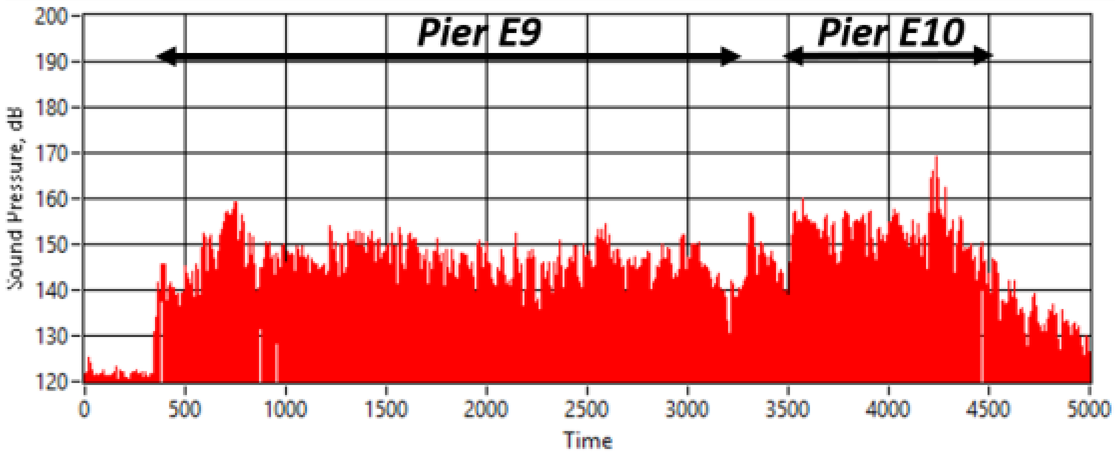

Figure 3-39. Sound Pressure Time History for Piers E9 and E10 at N2 (2,966 feet)

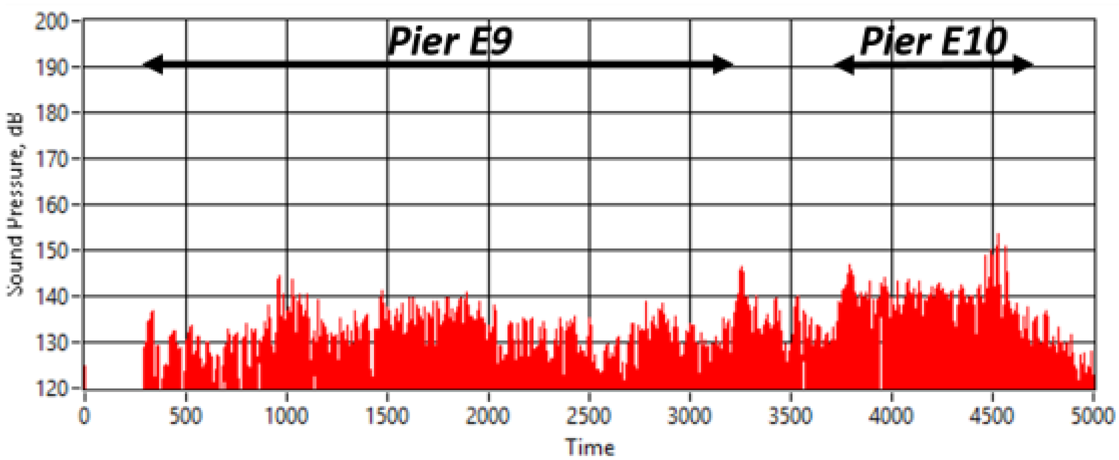

Figure 3-40. Sound Pressure Time History for Piers E9 and E10 at N3 (5,911 feet)

The sound pressure levels and cSEL levels at each of the far-field locations are shown in Figures 3-41 through 3-44. Including the 500 ms delay between the implosion of each pier, the total duration of the implosion event was about 3,850 ms, starting at about 800 ms and ending at about 4,650 ms, as shown in Figure 3-41. The cSEL initial increase at the beginning of the blast event, shown in this figure, is followed by two small incremental increases (of approximately 1 to 1.5 dB each) at the two greatest peaks during the Pier E9 implosion, and two steeper increases (of about 5 dB to 6 dB each) during the Pier E10 implosion. Overall, the cSEL increased by 11 dB from the end of the implosion of Pier E9 to the end of the implosion Pier E10. At location N1B, the cSEL difference between the end of the implosion of Pier E9 and end of the implosion of Pier E10 was about 6 dB (Figure 3-42). Furthermore, the peak levels throughout the Pier E9 implosion at location N1B (Figure 3-42) typically were about 5 to 10 dB higher than those at N1 (Figure 3-41), consistent with shielding of Pier E9 at N1. At further distances from the piers, the increase in cSEL became more gradual; however, the trend of higher levels for Pier E10 remained apparent (Figure 3-42 and Figure 3-44).

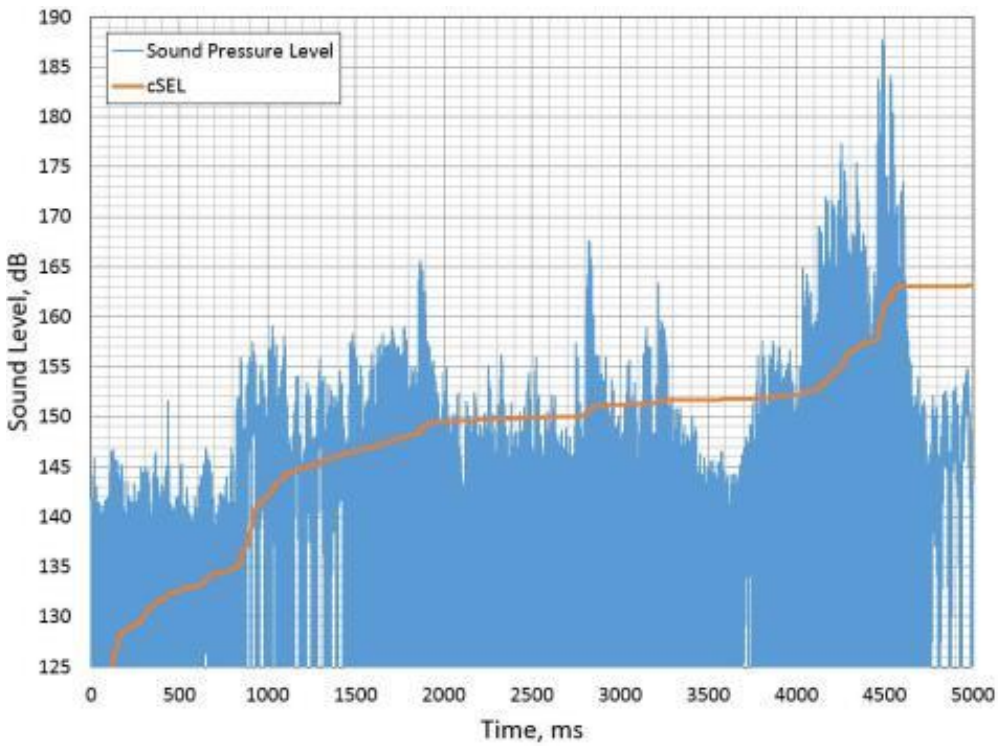

Figure 3-41. Sound Pressure Time History of Peak Sound Pressure Level and cSEL for Piers E9 and E10 at 1,579 feet (N1)

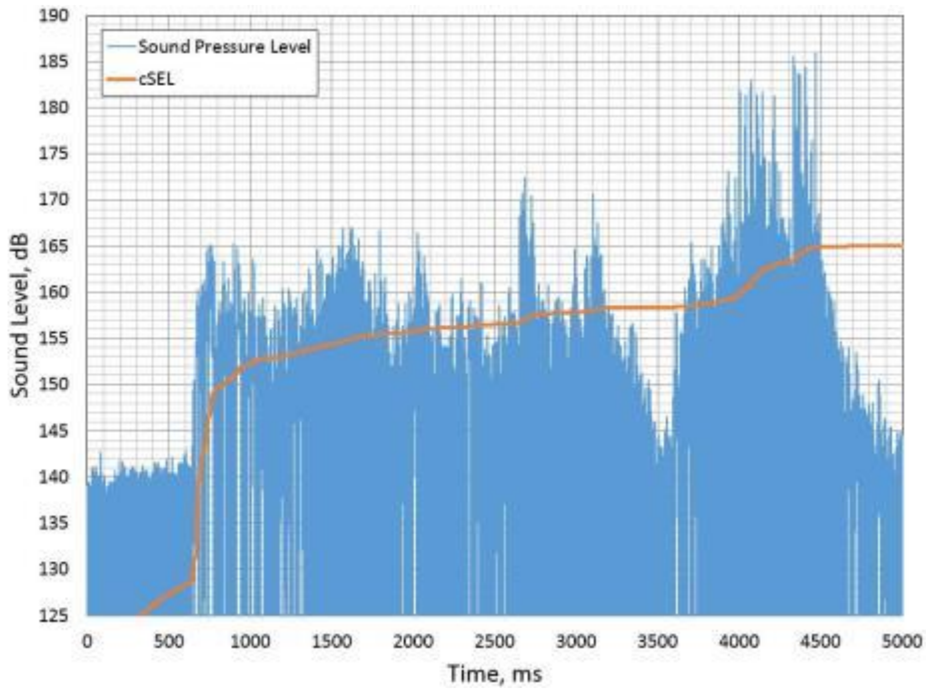

Figure 3-42. Sound Pressure Time History of Peak Sound Pressure Level and cSEL for Piers E9 and E10 at 1,431 feet (N1B)

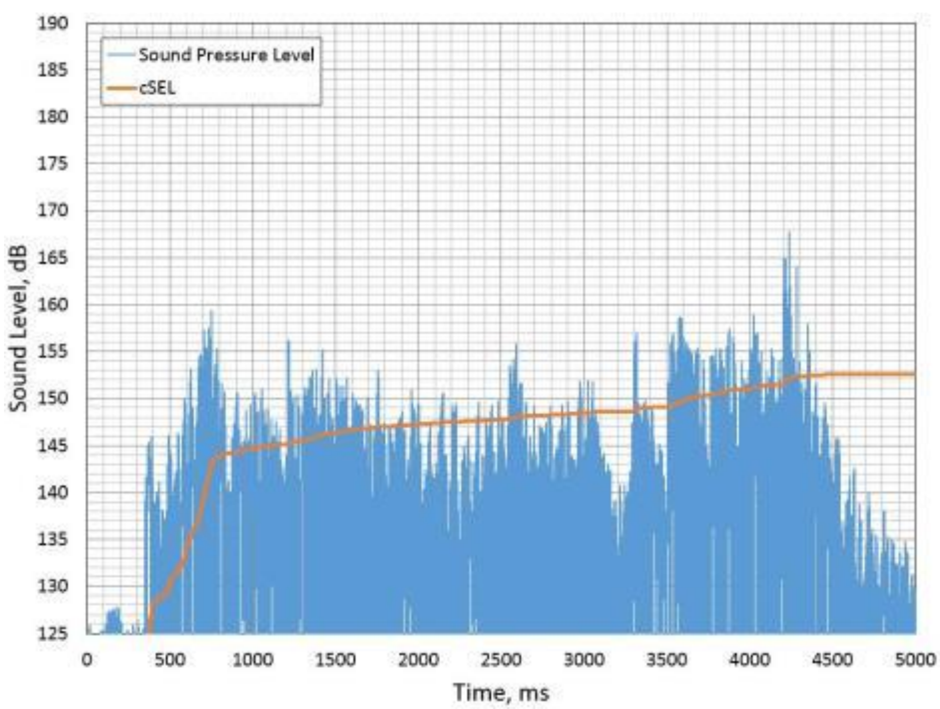

Figure 3-43. Sound Pressure Time History of Peak Sound Pressure Level and cSEL for Piers E9 and E10 at 2,966 feet (N2)

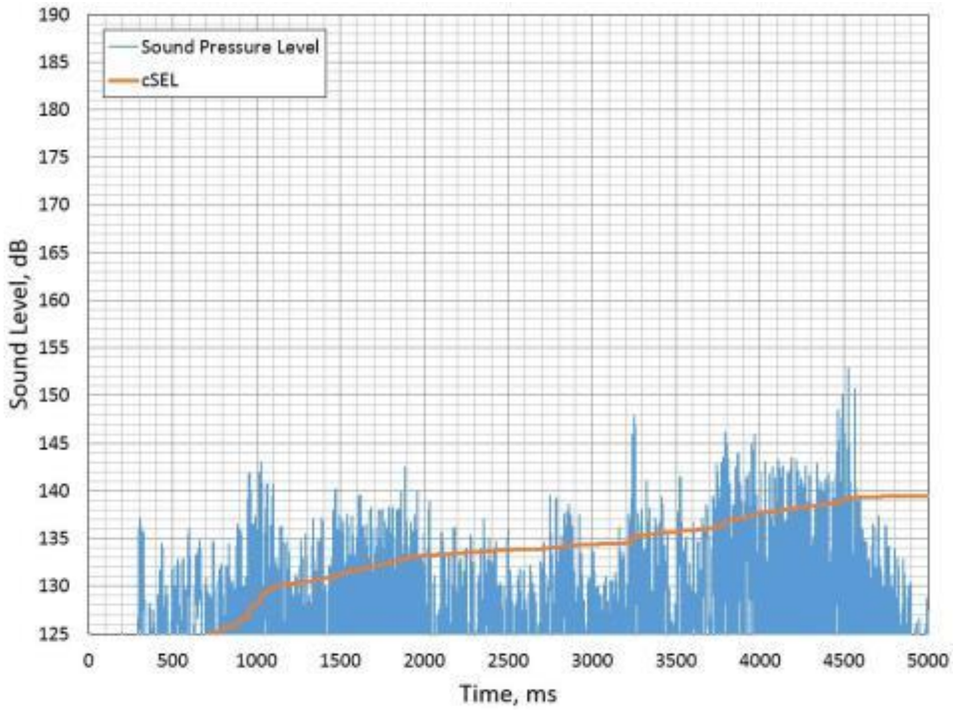

Figure 3-44. Sound Pressure Time History of Peak Sound Pressure Level and cSEL for Piers E9 and E10 at 5,911 feet (N3)

3.2.4. **Piers E11, E12 and E13**

On October 14, 2017, at approximately 8:20 a.m., Piers E11, E12, and E13 were imploded during a single blast event. The monitoring results captured during this blast event are shown in Table 3-7 for each location. The values include peak pressure in psi, peak sound pressure level in dB, cSEL in dB, and impulse pressure in psi-ms.

The peak sound pressure levels and cSEL values for Piers E11 through E13 versus distance from the pier, as well as the trend lines and the fish criteria, are shown in Figure 3-45. For these piers, the difference of the peak data points from the trend line is about 1 to 3 dB. Although the near-field cSEL data points lie close to the trend line, the far-field points are consistently lower than the trend line, by about 10 to 13 dB.

The impulse levels, trend lines, and marine mammal criteria are shown in Figure 3-46. The impulse level at the initial near-field location (178 feet [54 meters]) was more than 10 psi-ms, and at the second location (503 feet [153 meters]), the impulse level was 4.5 psi-ms. These elevated impulse levels shift the trend line up, and the curve crosses 0 dB around 3,000 feet (914 meters).

Table 3-7. Hydroacoustic Monitoring Results for the Implosion of Piers E11, E12, and E13

Location Name	Distance (feet)	Peak Pressure Level (pound per square inch)	Peak Sound Pressure Level (decibels)	cSEL (decibels)	Impulse (pounds per square inch-milliseconds)
S1	178[a]	25.30	224.8	205.6	12.35
S3	503[a]	5.10	210.9	193.8	4.53
S4	1,123[a]	1.83	202.0	185.1	2.70
N1	1,442	1.31	199.1	166.6	0.05
N2	2,965	0.21	183.3	160.3	0.01
N3	5,962	0.07	174.1	150.4	0.00

Note:

a. The distance provided in the table and used for the plots reflects the distance from the sensor to the pier with the maximum peak level.

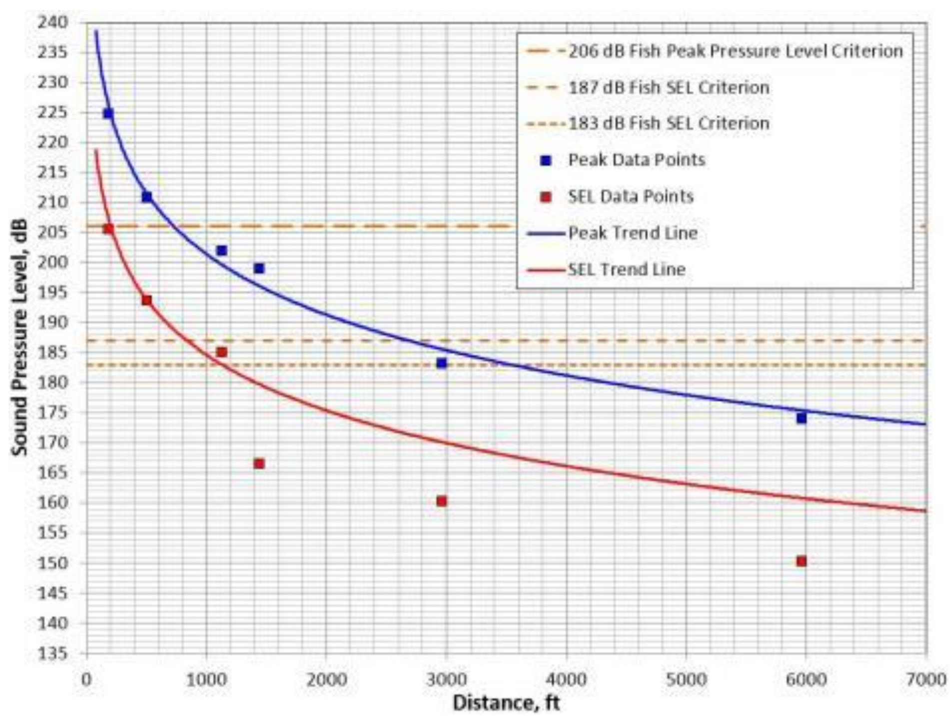

Figure 3-45. Piers E11 through E13 Peak Sound Pressure Levels and cSEL Values

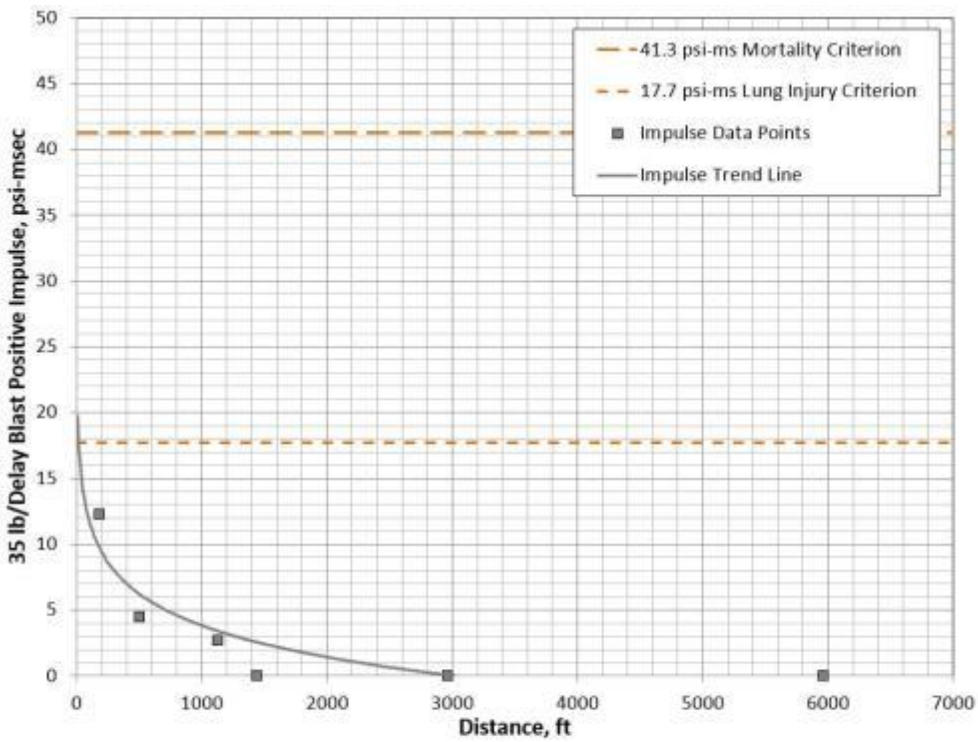

Figure 3-46. Piers E11 through E13 Impulse Levels

The time histories for the sound pressure levels at each of the near-field measurement locations are shown in Figures 3-47 through 3-49. At 178 feet (54 meters) (S1), the sound pressure levels for Pier E13 were substantially lower than the other two piers (Figure 3-47). Pier E13 was farther away from S1 than Piers E11 and E12, and this difference may have contributed to the lower Pier E13 levels at this location. At 503 feet (153 meters) south (S3), the levels of the three piers are all similar (Figure 3-48). At 1,123 feet (342 meters) (S4), the peak pressures for Piers E11 and E12 were similar and about 10 dB higher than Pier E13 (Figure 3-49). For all three piers, the progression of the implosions produced higher levels near the beginning of each event, with the levels dropping by 10 to 20 dB toward the end of each event.

The far-field time histories are shown in Figures 3-50 through 3-52. Unlike the near-field data, the far-field peak pressures for each pier increased as the implosion progressed through each pier, as the individual blasts progressed from south to north. A comparison between the peak pressure levels of the three piers also indicates a different trend than the near-field results. In the far field, Pier E13 consistently has the highest peak pressures, by 10 dB or more (Figures 3-50, 3-51, and 3-52). At 5,962 feet (1,817 meters) (N3), the difference between Pier E11 and Pier E13 is as much as 20 dB, although these piers had almost identical blast plans (Figure 3-52). Pier E12 was shielded from the far-field monitoring locations, and neither Pier E11 nor E13 was obscured by the piers of the new east span, likely contributing to the lower levels. Pier E11 did not appear to be shielded, and an explanation for the lower levels is not apparent.

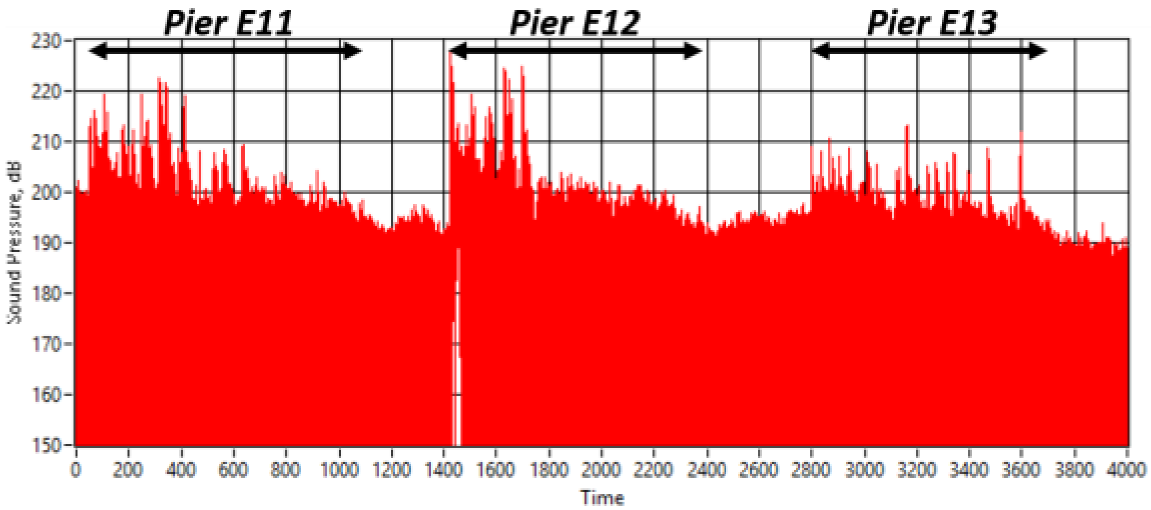

Figure 3-47. Sound Pressure Time History for Piers E11 through E13 at S1 (178 feet)

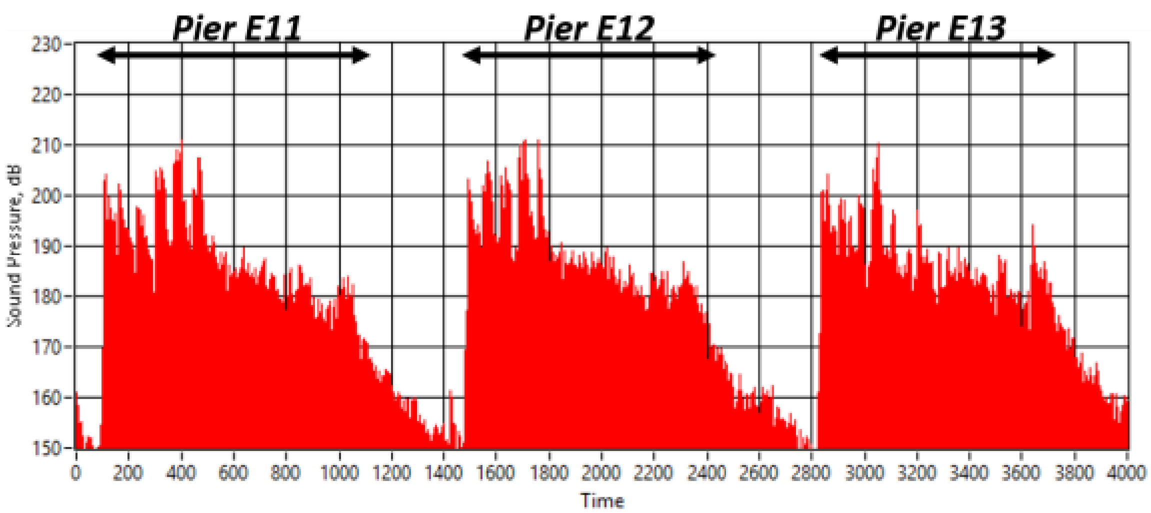

Figure 3-48. Sound Pressure Time History for Piers E11 through E13 at S3 (503 feet)

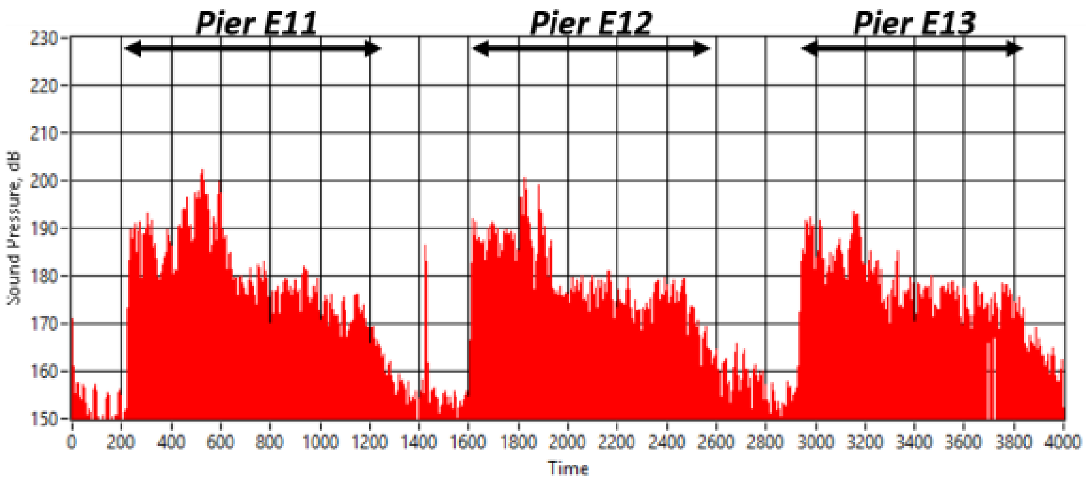

Figure 3-49. Sound Pressure Time History for Piers E11 through E13 at S4 (1,123 feet)

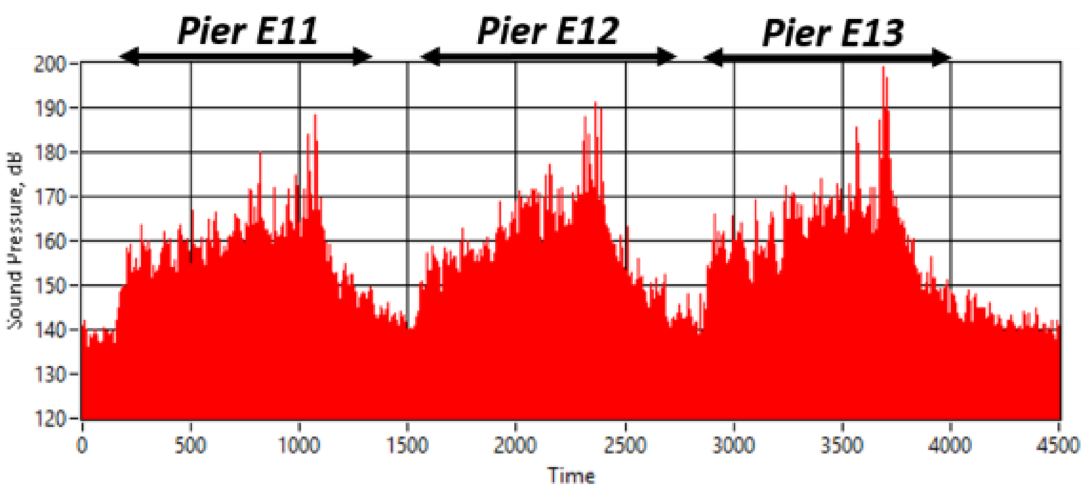

Figure 3-50. Sound Pressure Time History for Piers E11 through E13 at N1 (1,442 feet)

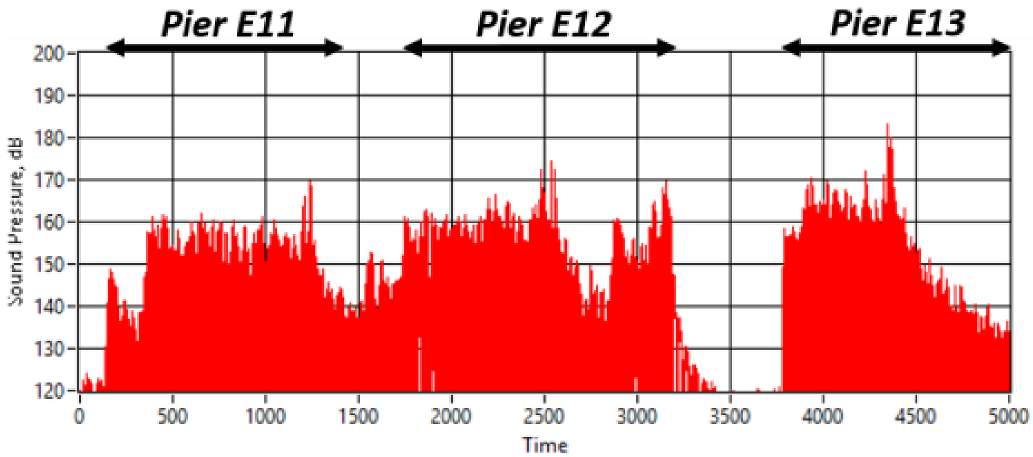

Figure 3-51. Sound Pressure Time History for Piers E11 through E13 at N2 (2,965 feet)

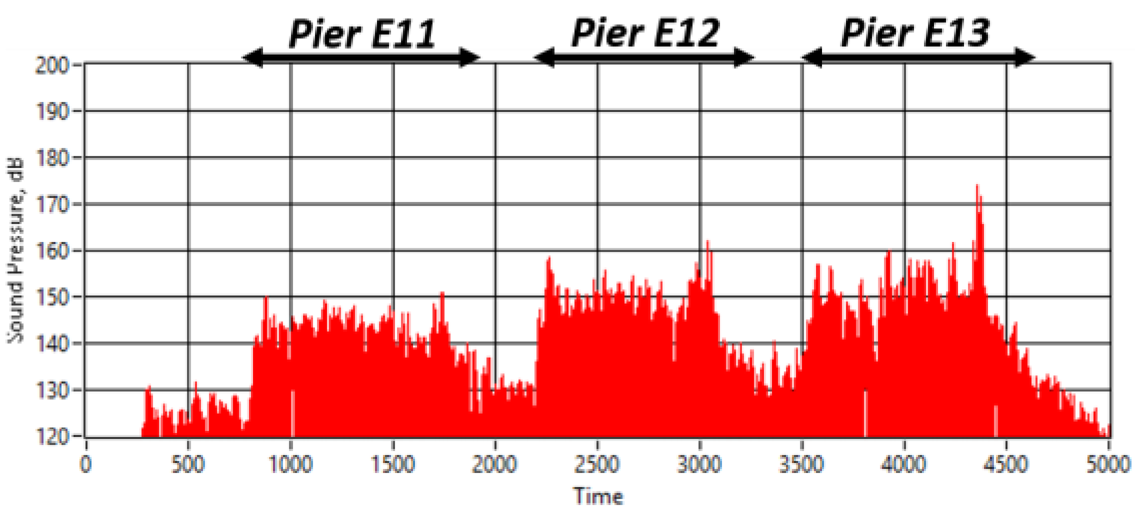

Figure 3-52. Sound Pressure Time History for Piers E11 through E13 at N3 (5,962 feet)

The sound pressure levels and cSEL levels at 2,965 feet (903 meters) and 5,962 feet (1,817 meters) north distances (N2 and N3) are shown in Figures 3-53 and 3-54. Because only a high-speed recording was made at N1, the cSEL could not be plotted for this location, as these are generated from the lower speed, solid-state recordings. The total duration of the implosion event was about 3,500 ms. Data at 2,965 feet (903 meters) north (N2) shows an apparent gap in the signal between about 400 and 450 ms (Figure 3-53). This occurred as the recorder transitioned from one wav file to the next, and no data was lost in this transition. Similar to results at N2, at 5,692 feet (1,734 meters) north (N3), the cSEL rose to 139 dB after Pier E11, made a gradual increase starting at Pier E12, and made another gradual increase at the start of Pier E13 (Figure 3-54).

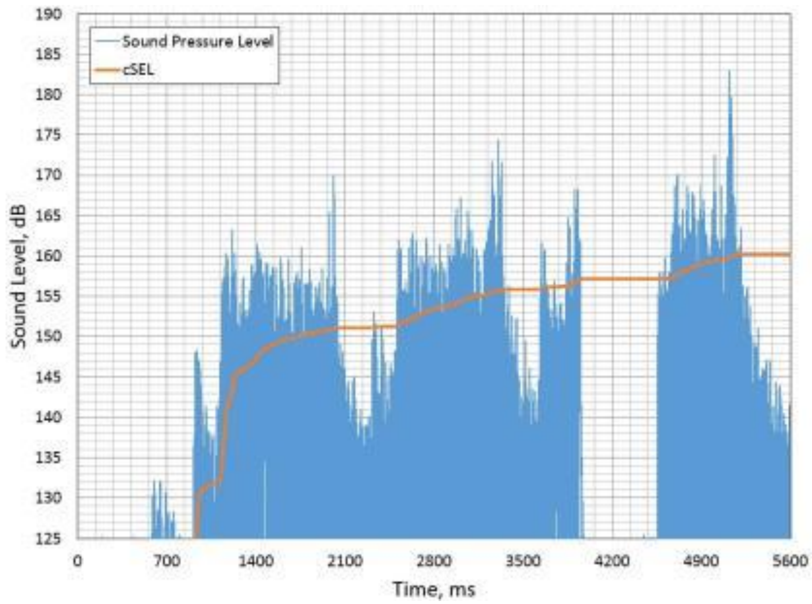

Figure 3-53. Sound Pressure Time History of Peak Sound Pressure Level and cSEL for Piers E11 through E13 at 2,965 feet (N2)

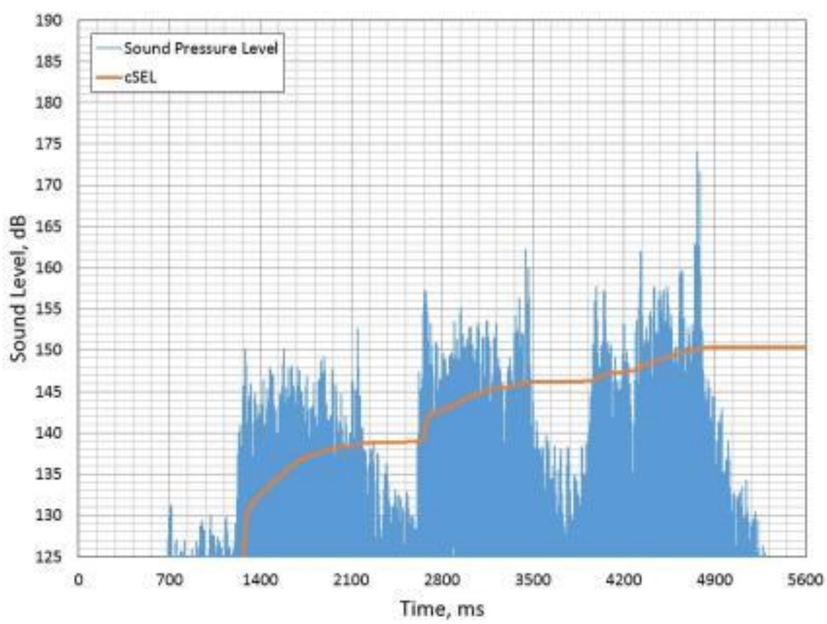

Figure 3-54. Sound Pressure Time History of Peak Sound Pressure Level and cSEL for Piers E11 through E13 at 5,962 feet (N3)

3.2.5. Piers E14, E15 and E16

Using the methods discussed above, the monitoring results during the Piers E14 through E16 implosions are shown in Table 3-8 for each location in the near field. The far-field locations were not monitored for this event. The values include peak pressure in psi, peak sound pressure level in dB, cSEL in dB, and impulse pressure in psi-ms.

The peak sound pressure levels and cSEL levels for Piers E14 through E16 versus distance from the pier, with the trend lines and the fish criteria, are shown in Figure 3-55. The impulse levels, trend line, and the marine mammal criteria are shown in Figure 3-56. The difference of the peak and cSEL data points from the respective trend lines is within 2 dB at each of the points; however, because only near-field data was taken during these implosion events, the differences are considerably less. The trend line for the impulse data crosses 0 dB around 1,600 feet (487 meters).

Table 3-8. Hydroacoustic Monitoring Results for the Implosion of Piers E14 through E16

Location Name	Distance (feet)	Peak Pressure Level (pound per square inch)	Peak Sound Pressure Level (decibels)	cSEL (decibels)	Impulse (pounds per square inch-milliseconds)
S1	177[a]	19.09	222.4	202.8	11.20
S2	515[a]	5.20	211.1	192.5	3.46
S3	788[a]	2.16	203.4	185.5	0.19
S4	1,203[a]	1.11	197.7	181.5	0.11

Note:

[a] The distance provided in the table and used for the plots reflects the distance from the sensor to the pier with the maximum peak level.

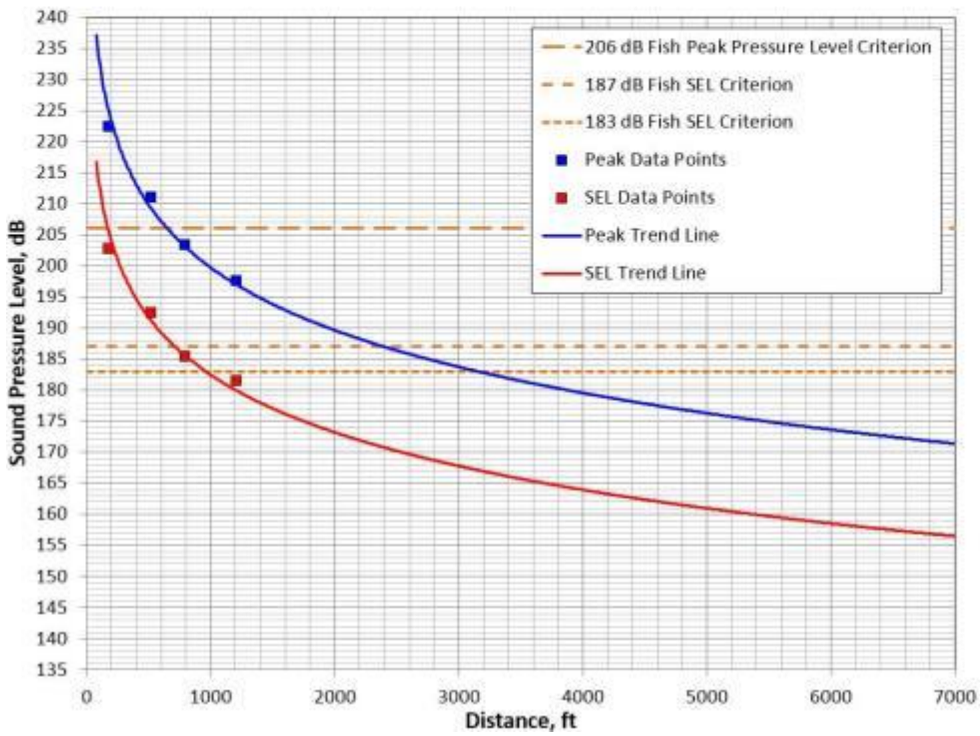

Figure 3-55. Piers E14 through E16 Peak Sound Pressure Levels and cSEL Values

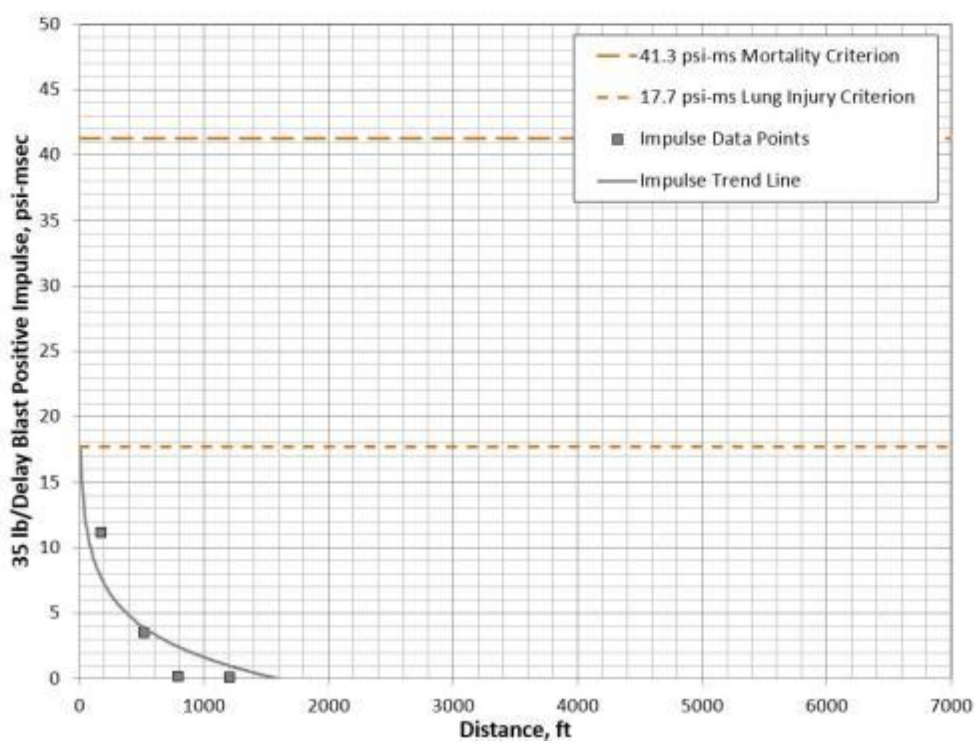

Figure 3-56. Piers E14 through E16 Impulse Levels

The time histories for the sound pressure levels at each of the near-field measurement locations are shown in Figures 3-57 through 3-60. At 177 feet (54 meters) south (S1), the peak pressure occurred during the implosion of Pier E15 (Figure 3-57). However, the peak pressure during the implosion of Pier E14 was within 2 dB of the peak during the implosion of Pier E15. The peak pressure for the Pier E16 implosion was about 10 dB lower than for Pier E15 at this location, because S1 was farther away from Pier E16, compared to the other piers. At 515 feet (257 meters) south (S2) (Figure 3-58) and 788 feet (240 meters) south (S3) (Figure 3-59), the peak pressure occurred during the implosion of Pier E14, and at 1,203 feet (366 meters) south (S4), the peak pressure occurred during the implosion of Pier E16 (Figure 3-60). However, the peak pressures during the implosion of each pier were within 5 dB of the maximum for each of these measurement locations. The implosion of the individual piers also indicates the progression of the blast plan from south to north, with higher levels occurring near the beginning of the implosions.

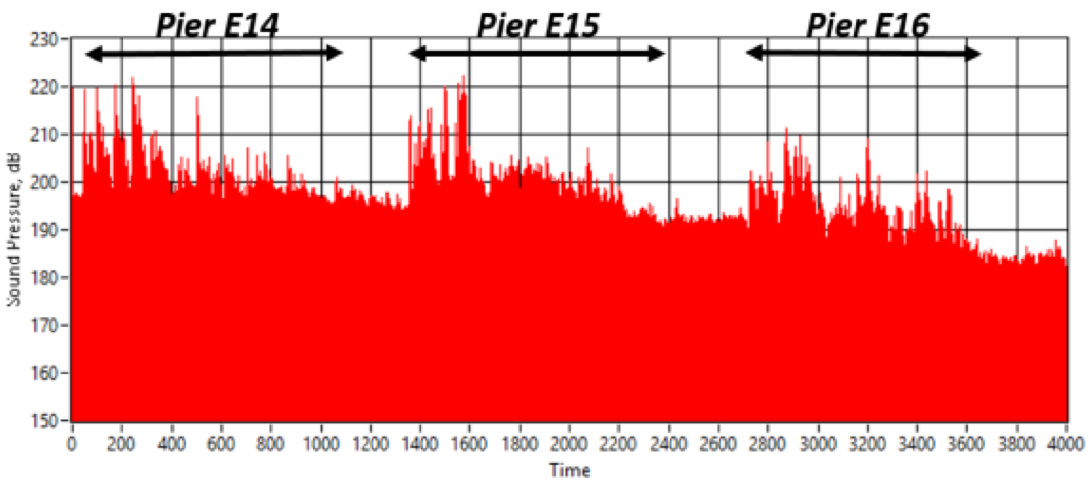

Figure 3-57. Sound Pressure Time History for Piers E14 through E16 at S1 (177 feet)

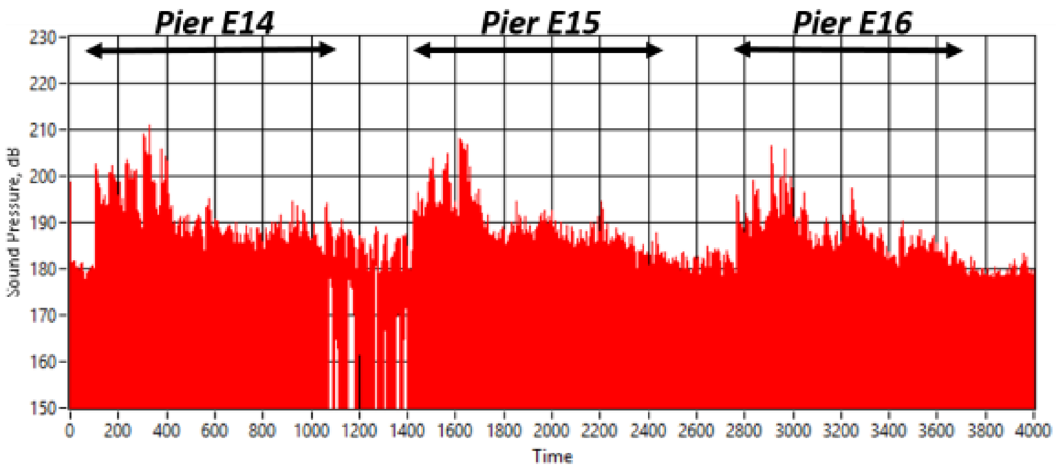

Figure 3-58. Sound Pressure Time History for Piers E14 through E16 at S2 (515 feet)

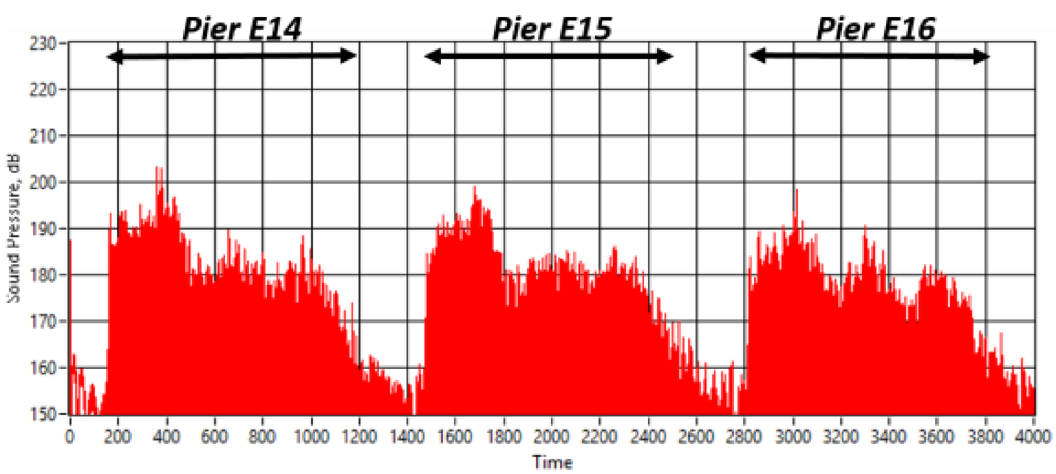

Figure 3-59. Sound Pressure Time History for Piers E14 through E16 at S3 (788 feet)

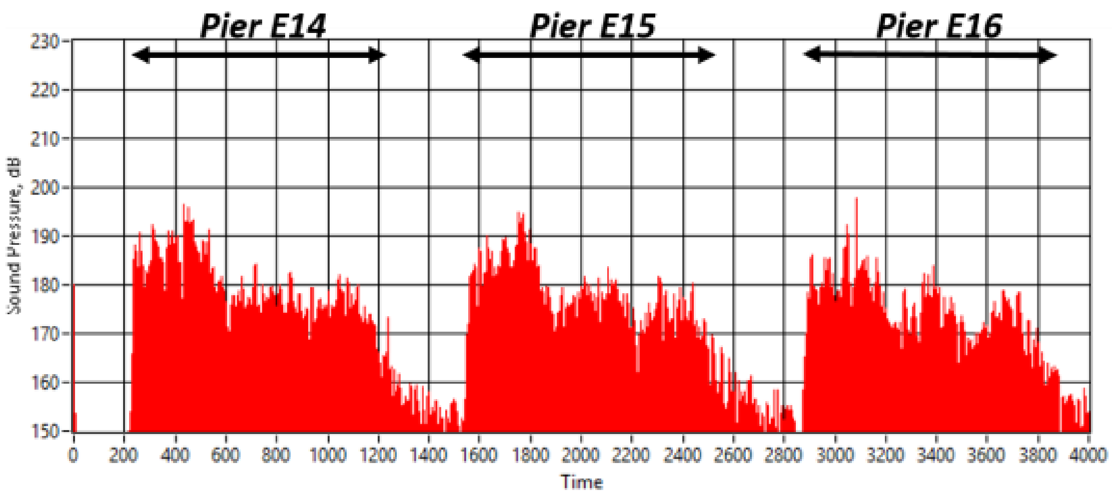

Figure 3-60. Sound Pressure Time History for Piers E14 through E16 at S4 (1,203 feet)

3.2.6. **Piers E17 and E18**

The monitoring results during the Piers E17 and E18 blast event are shown in Table 3-9 for each location. Monitoring in the far field was not conducted during this blast event. The values include peak pressure in psi, peak sound pressure level in dB, cSEL in dB, and impulse pressure in psi-ms.

The peak sound pressure levels and cSEL values and impulse levels for Piers E17 and E18 versus distance from the pier are shown in Figures 3-61 and 3-62. The respective trend lines and criteria also are shown in the figures. The differences between the data points and the trend lines are small. The impulse trend line shown in Figure 3-62 crosses 0 dB at about 900 feet (274 meters).

Table 3-9. Hydroacoustic Monitoring Results for the Implosion of Piers E17 and E18

Location Name	Distance (feet)	Peak Pressure Level (pound per square inch)	Peak Sound Pressure Level (decibels)	cSEL (decibels)	Impulse (pounds per square inch-milliseconds)
S1	185[a]	17.28	221.5	195.4	4.15
S2	488[a]	2.62	205.1	181.5	0.54
S3	796[a]	1.14	197.9	176.1	0.08
S4	1,158[a]	0.48	190.4	170.4	0.08

Note:

[a] The distance provided in the table and used for the plots reflects the distance from the sensor to the pier with the maximum peak level.

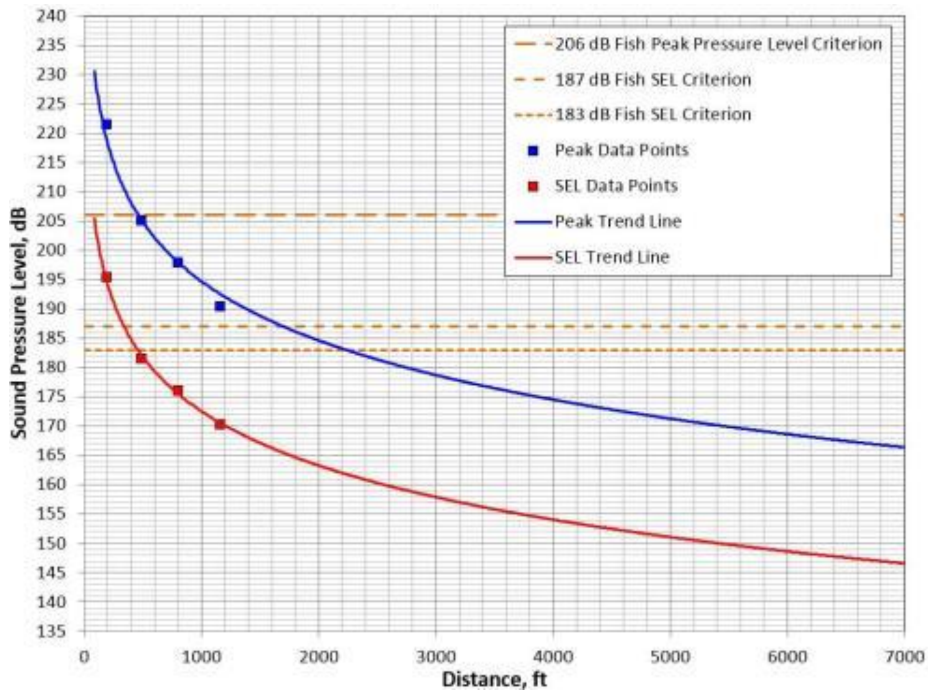

Figure 3-61. Piers E17 and E18 Peak Sound Pressure Levels and cSEL Values

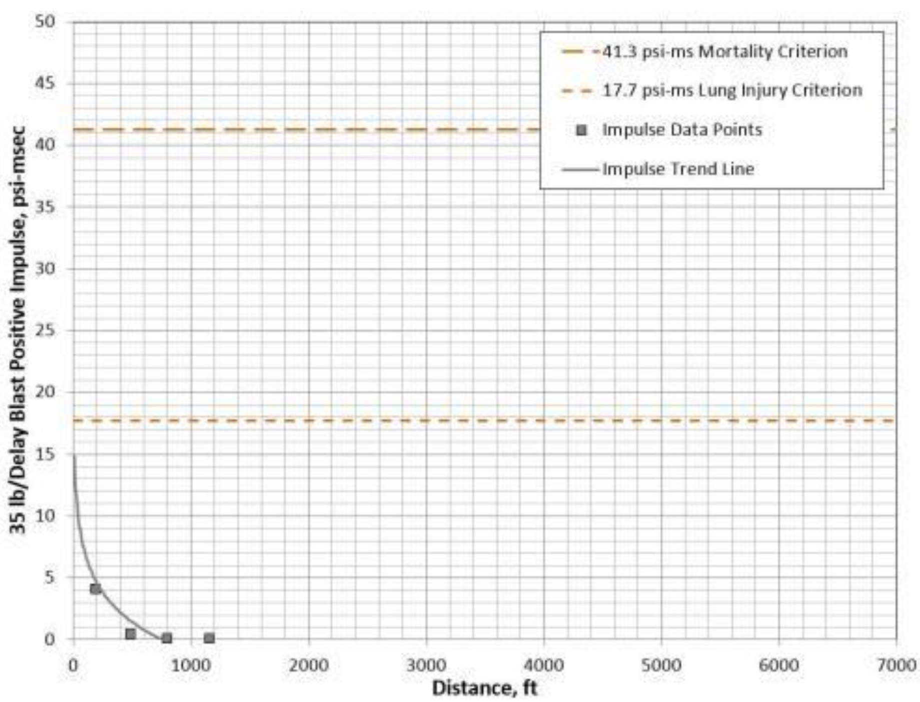

Figure 3-62. Piers E17 and E18 Impulse Levels

The time histories for the sound pressure levels at each of the measurement locations are shown in Figures 3-63 through 3-66. Because of the high noise floor in the pressure transducers, identifying the individual pier implosions is difficult at the 185 feet (56 meters) south (S1) and 488 feet (148 meters) south (S2) monitoring locations (Figures 3-63 and 3-64). However, the data that were collected using a hydrophone at 796 feet (242 meters) south (S3) clearly show that the Pier E17 implosion started just before 200 ms and ended around 1,200 ms, while the Pier E18 implosion started just before 1,700 ms and ended around 2,700 ms (Figure 3-65). Data collected with a hydrophone at 1,158 feet (353 meters) south (S4) had similar results, with the times shifted because of the greater distance from the piers. The peak pressures at S1, S2, and S3 occurred during the implosion of Pier E18 and ranged from being 5 to 15 dB higher than the observed peak during the Pier E17 implosion. The blast plans for these two piers were nearly identical, and the distance from the monitoring locations to the two piers was approximately the same (see Figure 3-66). At S4, an isolated peak at 600 ms in the Pier E17 implosion produced a slightly higher peak level (3 dB) than those for Pier E18. However, the peak levels were generally higher for Pier E18 than for Pier E17. Following the blast plans, the peak levels for each pier occurred in the first 400 ms of individual events, as the implosion progressed from south to north.

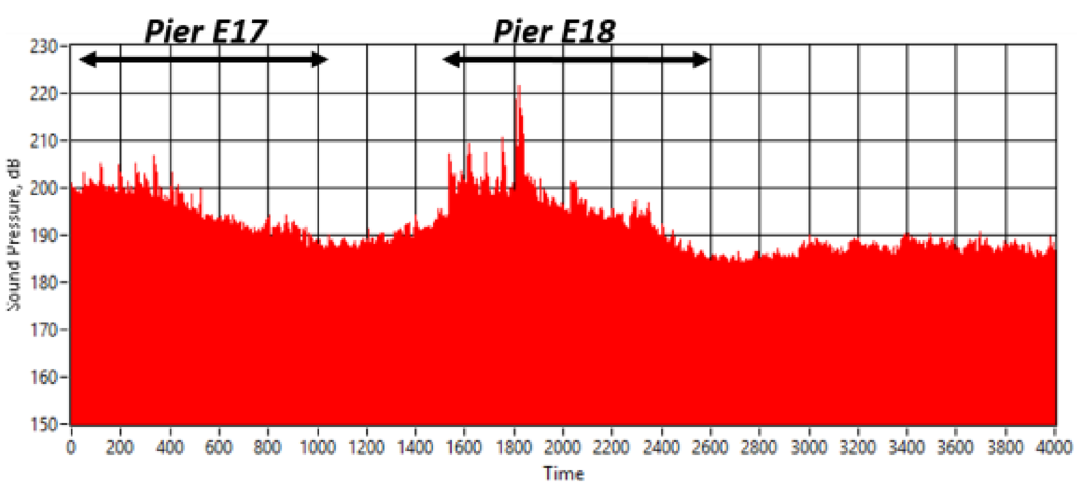

Figure 3-63. Sound Pressure Time History for Piers E17 and E18 at S1 (185 feet)

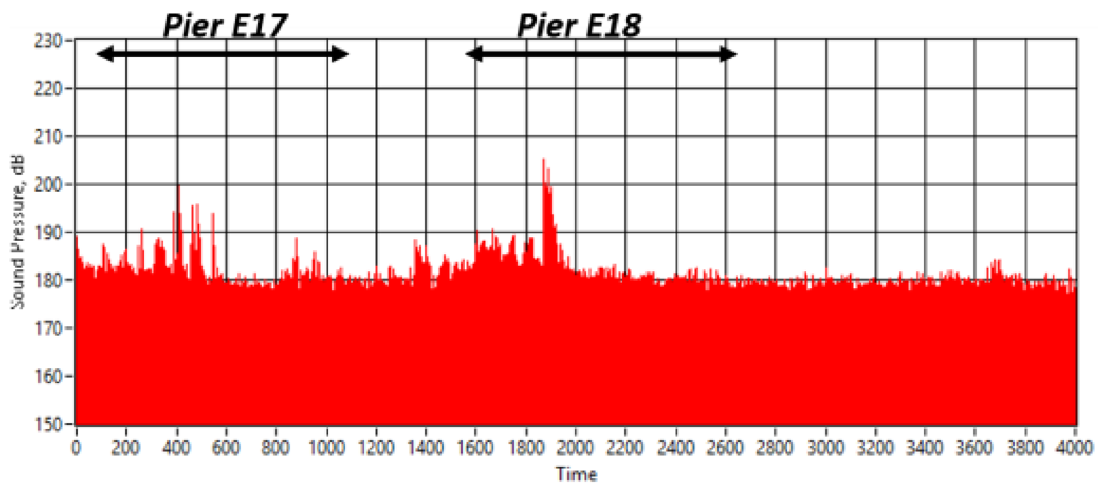

Figure 3-64. Sound Pressure Time History for Piers E17 and E18 at S2 (488 feet)

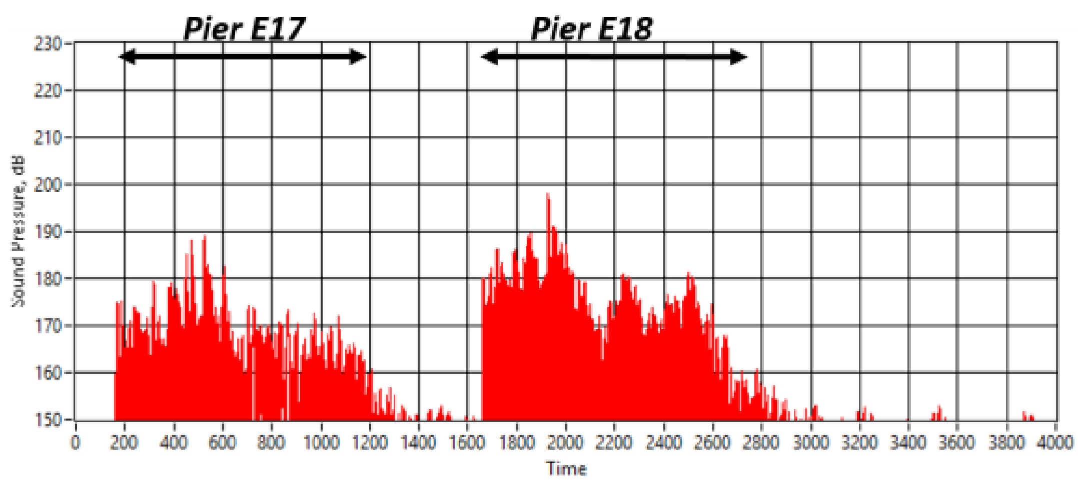

Figure 3-65. Sound Pressure Time History for Piers E17 and E18 at S3 (796 feet)

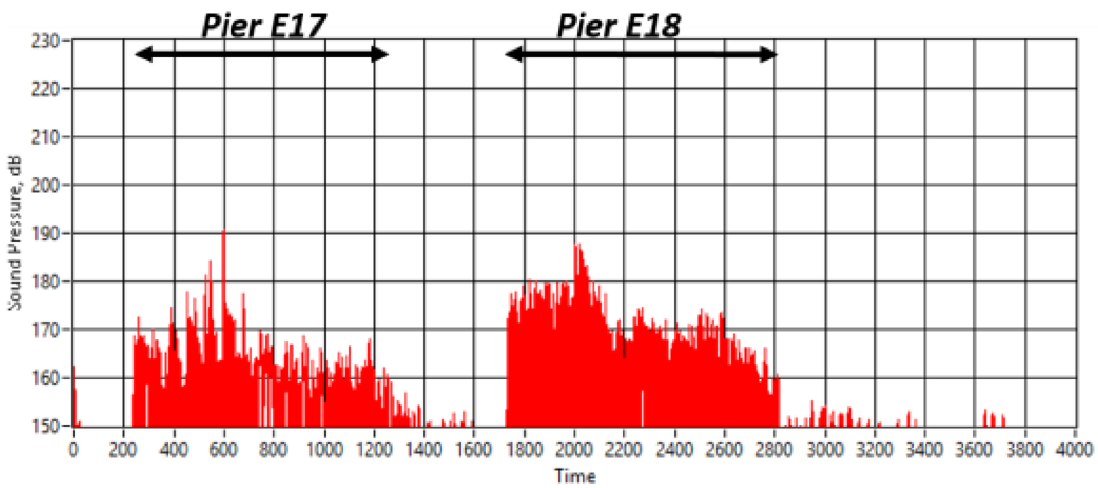

Figure 3-66. Sound Pressure Time History for Piers E17 and E18 at S4 (1,158 feet)

3.3. Conclusions

Hydroacoustic impacts on fish and marine mammal criteria are summarized in Chapter 5 and Chapter 7 of this report.

The hydroacoustic monitoring of Piers E6 through E18 is complete. If further monitoring during blast events becomes necessary to remove the remaining piers of the SFOBB original east span, some additional lessons should be considered for future implosion events. These include the following:

- Continue use of TC4013 hydrophones at near-field locations of 500 feet (152 meters) and beyond.
- Near and far-field monitoring should be done in the same direction along the same line and should extend out to 3,000 feet (914 meters) (or greater if possible).
- Measurement positions that are fully or partially obscured by the piers of the SFOBB new span should be avoided.
- To capture fast moving, in-water peak pressures generated by blasting events, use of high-speed recorders should continue at locations within 1,500 feet (457 meters) of the pier(s) to be imploded.

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Chapter 4. Marine Mammal Monitoring Results

Underwater blasting has the potential to result in the incidental take of marine mammals. On July 13, 2017, the Department was issued its 2017 IHA from NMFS, pursuant to the MMPA for the take of six species: California sea lion (*Zalophus californianus*), Pacific harbor seal (*Phoca vitulina richardii*), northern elephant seal (*Mirounga angustirostris*), northern fur seal (*Callorhinus ursinus*), harbor porpoise (*Phocoena phocoena*), and common bottlenose dolphin (*Tursiops truncatus*), by Level B harassment incidental to the controlled implosions of 13 piers of the SFOBB original east span (NMFS 2017; 82 Federal Register 35510).

The 2017 IHA allowed incidental take of the above species by Level B Harassment—Behavioral Response as well as Temporary Threshold Shift (TTS) at the quantities shown in Table 4-1. The number of marine mammals, by species, that may be taken was calculated based on distance to the threshold criteria, duration of the activity, and the estimated density of each species in the zone of influence (ZOI). Take of marine mammals by Level A Harassment–Permanent Threshold Shift (PTS), injury, or mortality was prohibited.

Table 4-1. Marine Mammal Take Allowed under the 2017 Incidental Harassment Authorization

Species	Level B Take	
	Behavioral	Temporary Threshold Shift
Pacific harbor seal	66	48
California sea lion	18	12
Northern elephant seal	6	3
Harbor porpoise	18	9
Bottlenose dolphin	6	3
Northern fur seal	6	3
Source: NMFS 2017; 82 Federal Register 35510, July 31, 2017		

4.1. Monitoring Methods

The 2017 IHA prescribed marine mammal monitoring requirements to be implemented before, during, and after underwater blasting activities. The goals of monitoring were to avoid Level A take of marine mammals, document Level B take within authorized take limits, and document any disturbance, harassment, or injury of marine mammals. In compliance with requirements of the 2017 IHA, the Department prepared a Marine Mammal Monitoring Plan, included in the 2017 Biological Monitoring Program.

4.1.1. **Marine Mammal In-Water Threshold Criteria**

NMFS has established sound threshold criteria for take of marine mammals from underwater blasting (Table 4-2). Hydroacoustic monitoring results from the implosions of Piers E3 in 2015 and Piers E4 and E5 in 2016 were used to estimate sound pressure and exposure levels, as well as to conservatively estimate the distances to these threshold criteria for the 2017 implosions of Piers E6 through E18. Methods to estimate and monitor the 2017 exclusion zones are described in Section 4.1.2 of this chapter. Hydroacoustic monitoring methods are described above in Chapter 3, and hydroacoustics monitoring results related to marine mammal thresholds are presented below in Section 4.3.

Table 4-2. Intermit Sound Threshold Criteria for Take of Marine Mammals from Underwater Blasting

<table>
<tr><th rowspan="2">Group/
Species</th><th colspan="2">Behavior</th><th colspan="3">Slight Injury</th><th rowspan="2">Mortality</th></tr>
<tr><th>Behavioral (for ≥ 2 pulses/ 24 hours)</th><th>TTS</th><th>PTS</th><th>Gastro Intestinal Tract</th><th>Lung</th></tr>
<tr><td>Low- frequency Cetaceans/ humpback whale</td><td>163 dB cSEL (LF_{II})</td><td>168 dB cSEL (LF_{II}) or 213 dB peak SPL</td><td>183 dB cSEL (LF_{II}) or 219 dB peak SPL</td><td rowspan="5">237 dB SPL or 104 psi</td><td rowspan="5">$39.1\ M^{1/3}(1+[D_{Rm}/10.081])^{1/2}$ Pa-sec Where: M = mass of the animals in kg D_{Rm} = depth of the receiver (animal) in meters</td><td rowspan="5">$91.4\ M^{1/3}(1+[D_{Rm}/10.081])^{1/2}$ Pa-sec Where: M = mass of the animals in kg D_{Rm} = depth of the receiver (animal) in meters</td></tr>
<tr><td>Mid-frequency Cetaceans/ bottlenose dolphin</td><td>165 dB cSEL (MF_{II})</td><td>170 dB cSEL (MF_{II}) or 224 dB peak SPL</td><td>185 dB cSEL (MF_{II}) or 230 dB peak SPL</td></tr>
<tr><td>High-frequency Cetaceans/ harbor porpoise</td><td>135 dB cSEL (HF_{II})</td><td>140 dB cSEL (HF_{II}) or 196 dB peak SPL</td><td>155 dB cSEL (HF_{II}) or 202 dB peak SPL</td></tr>
<tr><td>Pinnipeds–Phocidae/ harbor seal and elephant seal</td><td>165 dB cSEL (P_{WI})</td><td>170 dB cSEL (P_{WI}) or 212 dB peak SPL</td><td>185 dB cSEL (P_{WI}) or 218 dB peak SPL</td></tr>
<tr><td>Pinnipeds-Otariidae/ sea lion and northern fur seal</td><td>183 dB cSEL (O_{WI})</td><td>188 dB cSEL (O_{WI}) or 226 dB peak SPL</td><td>203 dB cSEL (O_{WI}) or 232 dB peak SPL</td></tr>
<tr><td colspan="7">Notes:
dB = decibel(s); cSEL = cumulative sound exposure level; Pa-sec = Pascal-second; PTS = Permanent Threshold Shift; RMS = root-mean-square; SPL = sound pressure level; TTS = Temporary Threshold Shift
All decibels are referenced to 1 micro Pascal (re: 1µPa).
Groups associated with cumulative sound exposure level thresholds indicate the designated marine animal auditory weighting function.
Source: Finneran and Jenkins 2012; NMFS 2016b</td></tr>
</table>

4.1.2. Monitoring Zones

The hydroacoustic monitoring results from the implosions of Piers E3, E4, and E5 were used to calculate distances to these thresholds for the implosions of Piers E6 through E18 (Department 2016, 2017b). Based on the calculated distances and in coordination with NMFS, the Department established specific Marine Mammal Exclusion Zones (MMEZs) and monitoring zones for each species group (or combined groups) for each type of blast event scenario. Level A MMEZs and Level B TTS and behavioral response monitoring zones were designed to be larger than the furthest calculated threshold distances (ZOI) appropriate to specific marine mammal functional hearing groups to create more conservative monitoring zones. These MMEZ and monitoring zone distances are shown in Tables 4-3 and 4-4.

Table 4-3. Pinniped and Bottlenose Dolphin Level A MMEZs and Level B TTS and Behavioral Response Monitoring Zones for 2017 Blast Events

	Level B Harassment Monitoring Zones		Level A Harassment MMEZ
Blast Scenario	**Behavioral (feet)**	**TTS (feet)**	**PTS (feet)**
Pier E6	2,664	1,781	532
Two 504-foot-span piers	2,148	1,423	400
Two 288-foot-span piers	1,631	1,080	367
Three 288-foot-span piers	1,896	1,254	367

Note:
MMEZ = marine mammal exclusion zone; TTS = Temporary Threshold Shift; PTS = Permanent Threshold Shift
Source: Compiled by AECOM in 2017

Table 4-4. Harbor Porpoise MMEZs and Level B TTS and Behavioral Response Monitoring Zones for 2017 Blast Events

	Level B Harassment Monitoring Zones		Level A Harassment MMEZ
Blast Scenario	**Behavioral (feet)**	**TTS (feet)**	**PTS (feet)**
Pier E6	15,080	10,030	2,951
Two 504-foot-span piers	12,360	8,160	2,359
Two 288-foot-span piers	9,240	6,168	1,877
Three 288-foot-span piers	11,284	7,080	2,066

Note:
MMEZ = marine mammal exclusion zone; TTS = Temporary Threshold Shift; PTS = Permanent Threshold Shift
Source: Compiled by AECOM in 2017

A minimum of ten NMFS-approved marine mammal observers (MMOs) conducted monitoring before, during, and after each blast event for the implosions of Piers E6 through E18. MMO positions were designated ahead of time, near the edge of each MMEZ and within monitoring zones. Monitoring stations included boats, bridge piers, the new SFOBB, and on locations at Treasure Island and YBI. Monitoring began a minimum of 30 minutes before the anticipated blast time, and continued for 60 minutes after the implosion.

Each MMO recorded his/her observation position, start and end times of observations, and weather conditions (e.g., sunny/cloudy, wind speed, fog, visibility). For each marine mammal sighting, the following items were recorded, if possible:

- species, number of animals (i.e., include with or without a dependent pup/calf);
- age class (i.e., pup/calf, juvenile, adult);
- identifying marks or color (e.g., scars, red pelage, damaged dorsal fin);
- position relative to pier implosion (i.e., distance and direction);
- movement (i.e., direction and relative speed);
- behavior (e.g., logging [resting at the surface], swimming, spy-hopping [raising above the water surface to view the area], foraging);
- signs of injury, stress, or other unusual behavior; and
- duration of sighting or times of multiple sightings of the same individual.

All MMOs were equipped with radios, using a dedicated marine mammal monitoring channel and with mobile phones as a back-up. One MMO, designated as the Lead MMO, was in constant contact with the Environmental Compliance Manager, who was with the Department's Resident Engineer and Blaster-in-Charge. The Lead MMO coordinated marine mammal sightings with the other MMOs. Each MMO contacted the other MMOs when a sighting was made within or near the MMEZs, so that the MMOs with overlapping areas of responsibility could continue to track the animal and the Lead MMO was aware of the animal's position.

If a sighting was within 30 minutes of the scheduled blast and an animal had entered an MMEZ or was near it, the Lead MMO was to notify the Department Environmental Compliance Manager and a delay protocol was to be implemented. If an animal was identified within the MMEZ or approaching the MMEZ, the animal was to be tracked until it left the zone. If it dove within the MMEZ and was not seen again, a 15-minute delay was to be implemented for pinnipeds and small cetaceans or a 30-minute delay for whales or other non-IHA listed species. The Lead MMO kept everyone informed of the location and disposition of the animal and was to notify the Department Environmental Compliance Manager if and when the MMEZs were clear before the implosion.

4.1.3. **Stranding Survey**

A stranding plan was prepared, in cooperation with the NMFS-designated marine mammal stranding, rescue, and rehabilitation center for central California. Although avoidance and minimization measures were anticipated to prevent any injuries from the implosions, preparations were made in the unlikely event that marine mammals were injured. Because sick, injured, or dead marine mammals could strand in the Bay for various reasons unrelated to the implosion activities, it was necessary to determine the cause of stranding for any marine mammals that appeared within 3 days after the implosion. Therefore, plans were made to examine sick or injured individuals that were observed after the implosion more thoroughly, to determine the cause of the stranding.

A stranding team member and a veterinarian for The Marine Mammal Center (TMMC) were staged near the project site at the time of the implosions to quickly recover any injured marine mammals, provide emergency veterinary care, and transport individuals to the stranding facility. In accordance with the 2017 IHA, NMFS (both the regional office and headquarters) were to be notified within the required timelines if any injured or dead animals were found, even if the animal appeared to be sick or injured from a cause other than the implosion.

Post-implosion stranding surveys were conducted immediately after the pier implosion events and over the following 3 days, to identify any injured or deceased marine mammals. The surveys were conducted by the Lead MMO; TMMC’s stranding team was present only during the first survey, conducted immediately following each pier implosion. Surveys began within 90 minutes after the implosion event, and each took approximately 4 hours to complete. TMMC’s stranding team was staged on the survey boat with nets, animal carriers, and a medical kit during the initial stranding survey.

Stranding surveys were conducted by boat and along the shoreline in the vicinity of the SFOBB new and original east spans (Figure 4-1). Boat surveys were conducted from Oakland Outer Harbor Berth 9 to Clipper Cove, counter-clockwise around Treasure Island and YBI. From YBI, the boat surveys included the moored barges on the north side of the new span, along the old east span piers, northeast toward Richmond, the Emeryville breakwater, and the Emeryville Crescent, before returning to Berth 9. Each survey path varied slightly, depending on field and tide conditions. Land surveys were conducted along the shoreline at the OTD, at the Emeryville Crescent, and along the shoreline north of the Oakland toll plaza and SFOBB approaches. The shoreline includes two stretches of sandy beach, riprap, and portions of Radio Road, which runs parallel to the north side of Highway 80 west-bound.

Figure 4-1. Stranding Survey Area

4.2. Monitoring Summary and Results

4.2.1. **Piers E7 and E8**

Implosion Monitoring

The implosion of Piers E7 and E8 occurred at 10:36 a.m. on September 2, 2017. Marine mammal monitoring was conducted from 7:35 to 11:40 a.m. A total of 78 harbor seals, 10 harbor porpoises, and three unidentified porpoises or dolphins were observed during the monitoring period on September 2. One harbor seal was observed within the Pinniped Level B TTS monitoring zone, and five harbor seals were observed within the Pinniped Level B behavioral response monitoring zone, within 15 minutes before the time of the blast. A summary of marine mammal take is shown in Table 4-5. A complete table showing all marine mammal sightings during the monitoring period for the September 2 implosions of Piers E7 and E8 is provided in Appendix A.

Table 4-5. Summary of Marine Mammal Take for the September 2, 2017 Implosions of Piers E7 and E8

	Level A Harassment	Level B Harassment	
Species Name	Permanent Threshold Shift	Temporary Threshold Shift	Behavioral Monitoring
Harbor seal	0	1	5
Source: Compiled by AECOM in 2017			

Stranding Surveys

The stranding surveys for the implosions of Piers E7 and E8 were conducted with TMMC immediately following the blast event on September 2, 2017; and then subsequently from September 3 to 5 by the Lead MMO only (Figure 4-1).

On September 2, 2017, the team observed five harbor seals in the water, and nine to 11 harbor seals at the YBI haul-out site during the post-implosion boat survey. No abnormal behavior or injuries were observed. One unknown animal dove near the out-of-range marker, west of Berth 9. On this day, no marine mammals were rescued by TMMC that showed any evidence of blast trauma in the Central Bay (TMMC, pers. comm., 2017). On September 3, the Lead MMO observed eight harbor seals in the water, with no abnormal behavior or injuries. No animals were hauled out at the YBI site, which was attributed to the survey occurring close to high tide. No marine mammals were observed during the land survey. On September 4, the Lead MMO observed five to six harbor seals in the water and 69 at the YBI haul-out site, during the boat survey. No marine mammals were observed during the land survey, and no marine mammals were reported to be stranded. On September 5, two harbor seals were observed in the water with normal behavior, during the boat survey. No marine mammals were observed during the land survey, and no marine mammals were reported to be stranded.

One moderately to advanced decomposed phocid was found on the beach on the west side of YBI (37.80999 N, 122.37190) on September 2, 2017. Per Section 8(f) and Section 9(b) of the IHA, notification was sent to NMFS. The veterinarian from TMMC and the Lead MMO determined the cause of death was unrelated to the implosion activities because the body was in a moderate to advanced state of decomposition. One sea lion was reported to TMMC at Hyde Street Pier in San Francisco, because of emaciation, and was being tracked on the morning of September 3 (TMMC, pers. comm., 2017). The emaciated sea lion at the Hyde Street Pier most probably was not related to the implosion activity. No other animals with abnormal behavior or injuries were observed between September 2 and 5.

4.2.2. Pier E6

Implosion Monitoring

The Pier E6 implosion occurred at 10 a.m. on September 16, 2017. Marine mammal monitoring was conducted from 7:31 to 11:03 a.m. A total of 35 harbor seals, three California sea lions, and eight harbor porpoises were observed during the monitoring period on September 16. Five harbor seals were observed within the Pinniped Level B TTS monitoring zone, and three harbor porpoises were observed milling just on the Harbor Porpoise Level B TTS monitoring zone border, within 15 minutes of the blast. An additional seven harbor seals that were not observed within this zone before the blast surfaced immediately following the blast within the Pinniped Level B TTS monitoring zone. A summary of marine mammal take is shown in Table 4-6. A complete table showing all marine mammal sightings during the monitoring period for the September 16 implosion of Pier E6 is provided in Appendix A.

Table 4-6. Summary of Marine Mammal Take for the September 16, 2017 Implosion of Pier E6

	Level A Harassment	Level B Harassment	
Species Name	Permanent Threshold Shift	Temporary Threshold Shift	Behavioral Monitoring
Harbor seal	0	12	0
Harbor porpoise	0	3	0
Source: Compiled by AECOM in 2017			

Stranding Surveys

The stranding surveys for the implosion of Piers E6 was conducted with TMMC immediately following the blast event on September 16, 2017; and then subsequently from September 17 to 19 by the Lead MMO only (Figure 4-1).

On September 16, 2017, the stranding team observed six harbor seals in the water, and three to four harbor seals at the YBI haul-out site during the boat survey. No abnormal behavior or injuries were observed. No stranded marine mammals were discovered along any of the shore areas. During that same time, no marine mammals were rescued by TMMC from any location in the Bay that showed any evidence of blast trauma (TMMC, pers. comm., 2017). On September 17, the Lead MMO observed seven harbor seals in the water, and 59 hauled out at YBI with no abnormal behavior or injuries. No strandings were reported to TMMC (TMMC, pers. comm., 2017). On September 18, the Lead MMO observed six harbor seals in the water with normal behavior near the USCG marina during the boat survey. No marine mammals were observed during the land survey. No marine mammals were reported to be stranded. On September 19, 12 harbor seals were observed in the water with normal behavior during the boat survey. Eight harbor seals were observed along the SFOBB new east span, near Piers E2 through E4. No marine mammals were observed during the land survey. No marine mammals were reported to be stranded.

One dead harbor seal was observed during the land survey on Toll Plaza Beach (37.82613, -122.31668) at 14:50 on September 17, 2017. TMMC's Stranding Team and NMFS were notified, per Section 8(f) and Section 9(b) of the IHA. The Lead MMO, in conjunction with TMMC, determined the time of death likely occurred more than a week and possibly several weeks earlier. Based on the advanced state of decomposition, it was determined that the cause of death of the animal was not likely related to implosion events. TMMC opted not to pick up the carcass, as a necropsy would not have been likely to yield any results because of its state. No other animals with abnormal behavior or injuries were observed between September 16 and 19.

4.2.3. **Piers E9 and E10**

Implosion Monitoring

The implosion of Piers E9 and E10 occurred at 9:23 a.m. on September 30, 2017. Marine mammal monitoring was conducted from 7:13 to 10:26 a.m. A total of 23 harbor seals, three California sea lions, and three harbor porpoise were observed during the monitoring period on September 30. Three harbor seals were observed within the Pinniped Level B TTS monitoring zone within 15 minutes of the blast. A summary of marine mammal take is shown in Table 4-7. A complete table showing all marine mammal sightings during the monitoring period for the September 30, 2017 implosions of Piers E9 and E10 is provided in Appendix A.

Table 4-7. Summary of Marine Mammal Take for the September 30, 2017 Implosion of Piers E9 and E10

	Level A Harassment	Level B Harassment	
Species Name	Permanent Threshold Shift	Temporary Threshold Shift	Behavioral Monitoring
Harbor seal	0	3	0
Source: Compiled by AECOM in 2017			

Stranding Surveys

A pre-blast land survey was conducted by the Lead MMO on September 29, 2017. Locations surveyed included the Emeryville Crescent, the shoreline of Radio Road east of the SFOBB toll plaza, and under the OTD (Figure 4-1). The dead harbor seal first observed on September 17 still was on the toll plaza beach. No new stranded animals and no live marine mammals were seen during the survey.

The stranding surveys for the implosion of Piers E9 were conducted with TMMC immediately following the blast event on September 30, and then subsequently from October 1 to 3 by the Lead MMO only.

On September 30, 2017, the team observed seven harbor seals in the water and three harbor seals at the YBI haul-out site during the boat survey. One harbor seal was observed feeding on fish at the opening of the Emeryville Crescent at 12:20 p.m. No abnormal behavior or injuries were observed. No stranded marine mammals were discovered along any of the shore areas. During that same time, no marine mammals were rescued by TMMC that showed any evidence of blast trauma (TMMC, pers. comm., 2017). On October 1, the Lead MMO observed five harbor seals in the water, with no abnormal behavior or injuries. No animals were hauled out at the YBI site. No marine mammals were observed during the land survey. On October 3, 13 harbor seals were observed in the water with normal behavior during the boat survey. Ten of the seals were seen together between the SFOBB new east span Piers E2 and E3. No animals were observed on or around the YBI haul-out site. No marine mammals were observed during the land survey. No marine mammals were reported to be stranded.

A dead harbor seal with degraded body parts was seen during the boat survey on October 3, 2017, floating near the Berth 9 channel, south of Interstate 80 and north of the Port of Oakland (37.81711 N, -122, 32594 W). TMMC was notified immediately, and the TMMC pathologist, in conjunction with the Lead MMO, determined that it had been dead approximately 7 to 10 days (TMMC, pers. comm., 2017). TMMC opted not to pick up the carcass because of its advanced decomposed state and determined it highly unlikely to be related to the Department's implosion activities. NMFS was notified about the animal, per Section 8(f) and Section 9(b) of the IHA. No other strandings, injuries, or animals with abnormal behavior were observed between September 29 and October 3.

Two bottlenose dolphins were observed off Alameda Island on October 3, 2017 (GGCR 2017). No other cetacean sightings were reported between September 29 and October 3.

4.2.4. **Piers E11, E12 and E13**

Implosion Monitoring

The implosion of Piers E11, E12, and E13 occurred at 8:51 a.m. on October 14, 2017. Marine mammal monitoring was conducted from 7:04 to 09:53 a.m. A total of 43 harbor seals, two California sea lions, and two harbor porpoise were observed during the monitoring period on October 14. There was one harbor seal observed within the Pinniped Level B TTS monitoring zone, and two harbor seals observed within the Pinniped Level B behavioral response monitoring zone within 15 minutes prior to the blast. These animals were presumed to be present during the blast and were counted as take. Two additional harbor seals, one observed within the Level B TTS zone and one within the Level B behavioral zone, surfaced immediately after the blast. These animals were also counted as take.. A summary of marine mammal take is shown in Table 4-8. A complete table showing all marine mammal sightings during the monitoring period for the October 14 implosions of Piers E11, E12, and E13 is provided in Appendix A.

Table 4-8. Summary of Marine Mammal Take for the October 14, 2017 Implosion of Piers E11, E12, and E13

	Level A Harassment	Level B Harassment	
Species Name	**Permanent Threshold Shift**	**Temporary Threshold Shift**	**Behavioral Monitoring**
Harbor seal	0	2	3
Source: Compiled by AECOM in 2017			

Stranding Surveys

A pre-blast land survey was conducted by the Lead MMO on October 13, 2017. The Emeryville Crescent west of Interstate 580, the shoreline at the end of Radio Road, the shoreline at the SFOBB toll plaza, and under the OTD were surveyed (Figure 4-1). No new stranded or live animals were observed. Two sea lions were reported to be stranded on Alameda Island before October 14 (TMMC, pers. comm., 2017). One of the animals was near Jack London Square, and the other, with a head injury, was at Ballena Isle Marina.

The stranding surveys for the implosions of Piers E11, E12, and E13 were conducted with TMMC immediately following the blast event on October 14, 2017, and then subsequently from October 15 to 17 by the Lead MMO only.

On October 14, 2017, the team observed 19 harbor seals in the water and three harbor seals at the YBI haul-out site during the boat survey. One of the 19 observed harbor seals displayed abnormal behavior, described next. No stranded marine mammals were discovered along any of the shore areas. During that same time, no marine mammals that showed any evidence of blast trauma were rescued by TMMC (TMMC, pers. comm., 2017). On October 15, the Lead MMO observed three harbor seals in the water, one with abnormal behavior. No animals were hauled out at the YBI site. On October 16, the Lead MMO observed 17 harbor seals in the water and 32 to 38 at the YBI haul-out site during the boat survey. No marine mammals were observed during the land survey. No harbor seals that were observed on October 16 displayed abnormal behavior. On October 17, seven harbor seals were observed in the water during the boat survey.

No new marine mammals were observed during the land survey, but the dead animal that first was observed on October 3, floating near the Berth 9 channel, was observed on the beach west of the construction contractor's yard. The animal was confirmed to be the same because of coat color pattern, sloughing of skin, and location. NMFS was notified, per Section 8(f) and Section 9(b) of the IHA.

Two harbor porpoises (a potential calf-cow pair) were observed approximately one-half nautical mile (926 meters) north of Treasure Island during the boat survey on October 15, 2017. No other cetacean sightings were reported between October 14 and 17.

4.2.5. **Piers E14, E15 and E16**

Implosion Monitoring

The implosion of Piers E14, E15, and E16 occurred at 7:49 a.m. on October 28, 2017. Marine mammal monitoring was conducted from 7 to 8:50 a.m. A total of 15 harbor seals were observed during the monitoring period on October 28. No marine mammals were observed in any of the marine mammal monitoring zones within 15 minutes before the time of the implosion, and thus no Level B take occurred during this implosion event. A complete table showing all marine mammal sightings during monitoring for the October 28, 2017 blast of Piers E14, E15, and E16 is provided in Appendix A.

Stranding Surveys

A pre-blast land survey was conducted by the Lead MMO on October 27, 2017. The Emeryville Crescent west of Interstate 580, the shoreline at the end of Radio Road, the shoreline at the SFOBB toll plaza, and under the OTD were surveyed (Figure 4-1). No new stranded animals or live animals were observed.

The stranding surveys for the implosions of Piers E14, E15, and E16 were conducted with TMMC immediately following the blast event on October 28, 2017, and then subsequently between October 29 and 31 by the Lead MMO only.

On October 28, 2017, the team observed eight harbor seals in the water and two harbor seals at the YBI haul-out site during the boat survey. No abnormal behavior or injuries were observed. No stranded marine mammals were discovered along any of the shore areas. During that same time, no marine mammals that showed any evidence of blast trauma were rescued by TMMC (TMMC, pers. comm., 2017). On October 29, the Lead MMO observed nine harbor seals in the water and 46 at the YBI haul-out site, with no abnormal behavior or injuries. No marine mammals were observed during the land survey. No animals were reported to be stranded. On October 30, the Lead MMO observed one harbor seal in the water and 56 at the YBI haul-out site. No marine mammals were observed during the land survey. No marine mammals were reported to be stranded. On October 31, four harbor seals were observed in the water with normal behavior during the boat survey. One harbor seal was observed during the land and boat survey, floating with its back above the water approximately 600 feet (183 meters) off the Emeryville Crescent. It dove and resurfaced normally. No marine mammals were reported to be stranded. No other animals with abnormal behavior or injuries were observed between October 27 and October 31.

Two harbor porpoises (cow-calf pair) were observed near Channel Marker 9 near the entrance to Oakland Outer Harbor on October 30, 2017. The (presumed) same pair was seen approximately 500 feet (152 meters) west of Treasure Island during the boat survey on October 31. No other cetacean sightings were reported.

4.2.6. **Piers E17 and E18**

Implosion Monitoring

The implosion of Piers E17 and E18 occurred at 07:27 a.m. on November 11, 2017. Marine mammal monitoring was conducted from 6:10 to 8:28 a.m. A total of 21 harbor seals were observed during the monitoring period on November 11. All marine mammal sightings during monitoring for the November 11 implosions of Piers E17 and E18 are shown in Table 4-9. A complete table showing all marine mammal sightings during the monitoring period for the November 11 implosions of Piers E17 and E18 is provided in Appendix A.

Table 4-9. Summary of Marine Mammal Take for the November 11, 2017 Implosion of Piers E17 and E18

Species Name	Level A Harassment	Level B Harassment	
	Permanent Threshold Shift	**Temporary Threshold Shift**	**Behavioral Monitoring**
Harbor seal	0	2	1
Source: Compiled by AECOM in 2017			

Harbor seal activity within the Level A Harassment Exclusion Zone delayed the blast from its original scheduled time of 07:10 a.m. One harbor seal surfaced approximately 150 feet south of Pier E18 at 06:57 a.m. The IHA delay protocol (described in detail in Section 2.1.2) was implemented and the blast time was moved to 07:13 a.m. Another harbor seal surfaced at 07:12 a.m. along the southern edge of the exclusion zone. The blast was further delayed until 07:27 a.m., according to delay protocol. Time was precisely kept by the Lead MMO and was communicated to the Department Environmental Compliance Manager in order to notify the Department Environmental Compliance Manager and Blaster in Charge if and when the MMEZs were clear before the implosion. No marine mammals were observed in the Level A Harassment Exclusion Zone within 15 minutes of the blast. One harbor seal was observed within the Pinniped Level B TTS monitoring zone, and one harbor seal was observed within the Pinniped Level B behavioral response monitoring, within 15 minutes of the blast.

An additional harbor seal was seen just inside the 367-foot (112-meter) Pinniped Level A PTS MMEZ, at a distance of 300 feet (91 meters) just after the blast. However, based on hydroacoustic measurements collected in the field during the implosion, the actual distance to the Level A PTS threshold was 221 feet (67 meters). Therefore, the animal would not have been exposed to sound levels resulting in a Level A PTS take but is counted as a TTS take. Measured hydroacoustic results for the pier implosion events relative to implemented exclusion and monitoring zone are discussed further in Section 4.3 of this chapter.

Stranding Surveys

A pre-blast land survey was conducted by the Lead MMO on November 10, 2017. The Emeryville Crescent west of Interstate 580, the shoreline at the end of Radio Road, the shoreline at the SFOBB toll plaza, and under the OTD were surveyed (Figure 4-1). No new stranded or live animals were observed.

The stranding surveys for the implosions of Piers E17 and E18 were conducted with TMMC immediately following the blast event on November 11, 2017; and then subsequently between November 12 and 14 by the Lead MMO only.

On November 11, 2017, the team observed four harbor seals in the water and 20 harbor seals at the YBI haul-out site during the boat survey. No abnormal behavior or injuries were observed. No other stranded marine mammals were discovered along any of the shore areas. During that same time, no marine mammals that showed any evidence of blast trauma were rescued by TMMC (TMMC, pers. comm., 2017). On November 12, the Lead MMO observed 16 harbor seals in the water and 39 at the YBI haul-out site, with no abnormal behavior or injuries. No marine mammals were observed during the land survey. On November 13, the Lead MMO observed four harbor seals in the water and six at the YBI haul-out site. No marine mammals were observed during the land survey. No marine mammals were reported to be stranded. On November 14, 13 harbor seals were observed in the water and four were hauled out at the YBI haul-out site with normal behavior and no visible injuries. No marine mammals were reported to be stranded.

TMMC received reports of a lethargic sea lion at Candlestick Cove on November 12, 2017, but was unable to verify the report. An entangled sea lion also was reported at Pier 39 on the same day but was inaccessible for rescue (TMMC, pers. comm., 2017). One unidentified pinniped was reported with a bite wound at Rincon Park on November 13, but returned to the water on its own and was not rescued.

A lone harbor porpoise was observed approximately 1 nautical mile north of Treasure Island, as well as a group of three porpoises (two adults, one juvenile) approximately 1,000 feet (304 meters) west of the junction of Treasure Island and YBI during the boat survey on November 13, 2017. No other cetacean sightings were observed or reported between November 10 and November 13.

4.3. Hydroacoustic Monitoring Results

Hydroacoustic monitoring was conducted during the implosions of Piers E6 through E18, to verify distances to the MMEZs and monitoring zones. As previously discussed, measured distances to marine mammal threshold criteria from the implosions of Pier E3 in 2015 and the implosions of Piers E4 and E5 in 2016 were used to estimate the distances to these threshold criteria for the implosions of Piers E6 through E18. The Level A PTS MMEZ and Level B TTS and behavioral response monitoring zones were intentionally designed to be larger than the furthest calculated threshold distances (ZOI) appropriate to specific marine mammal functional hearing groups to create more conservative monitoring zones (Table 4-2). The pinniped and dolphin exclusion and monitoring zones were based on estimated distances to threshold criteria for phocids (harbor seal and elephant seal). The distances to the Level A and Level B threshold criteria for otariids (sea lion and fur seal) and the mid-frequency cetaceans (bottlenose dolphin) are less than the distance to the phocids (harbor seal and elephant seal) threshold criteria. As the exclusion zones for otariids (sea lions and northern fur seals) and bottlenose dolphin would be in the near field of the implosion and to simplify monitoring procedures, the Department elected to monitor a larger Level A exclusion zone and Level B TTS and behavioral monitoring zones for otariids and bottlenose dolphin.

The measured distances to Level A PTS and Level B TTS and behavioral threshold criteria from the implosions of Pier E6 to E18 were variable. The estimated distances to marine mammal threshold criteria, distances to exclusion and monitoring zones implemented during the pier implosions, and measured distances to threshold criteria are shown in Tables 4-10 through 4-15. Instances in which measured distances to marine mammal threshold criteria were greater than the estimated distances and/or implemented exclusion and monitoring zones are noted in the tables. For implosion events involving one pier (Pier E6), two 288-foot-span piers, two 504-foot-span piers (Piers E7 and E8) measured distances to marine mammal threshold criteria were less than the estimated distances and implemented exclusion and monitoring zones.

For the pier implosion event involving one 288-foot span pier (Pier E10) and one 504-foot-span pier (Pier E9) measured distances to marine mammal threshold criteria exceeded some of the estimated distances and implemented exclusion and monitoring zones that had been developed for the implosion of two 504-foot-span piers.

For both pier implosion events involving three 288-foot-span piers, measured distances to marine mammal threshold criteria exceeded some of the estimated distances and implemented exclusion and monitoring zones.

Table 4-10. Measured Distances to Underwater Blasting Threshold Criteria Compared to Estimated Distances and Implemented Exclusion and Monitoring Zones for Implosion of Piers E7 and E8

Species Group		Behavioral	TTS		PTS	
Mid-Frequency Cetaceans (dolphins)	Threshold	165 dB cSEL	224 dB peak	170 dB cSEL	230 dB peak	185 dB cSEL
	Two 504-foot-span Pier Estimated Distances (feet)	1,055	166	685	90	190
	Exclusion and Monitoring Zones (feet)	2,148	1,423		400	
	Piers E7–E8 Measured Distances (feet)	504	91	354	60	123
High-Frequency Cetaceans (porpoises)	Threshold	135 dB cSEL	196 dB peak	140 dB cSEL	202 dB peak	155 dB cSEL
	Two 504-foot-span Pier Estimated Distance (feet)	10,300	2,882	6,800	1,564	1,966
	Exclusion and Monitoring Zones (feet)	12,360	8,160		2,359	
	Piers E7–E8 Measured Distances (feet)	3,694	619	2,596	410	901
Phocid Pinnipeds (seals)	Threshold	165 dB cSEL	212 dB peak	170 dB cSEL	218 dB peak	185 dB cSEL
	Two 504-foot-span Pier Estimated Distances (feet)	1,790	565	1,186	306	333
	Exclusion and Monitoring Zone Distances (feet)	2,148	1,423		400	
	Piers E7–E8 Measured Distances (feet)	901	206	632	137	218
Otariid Pinnipeds (sea lions)	Threshold	183 dB cSEL	226 dB peak	188 dB cSEL	232 dB peak	203 dB cSEL
	Two 504-foot-span Pier Estimated Distances (feet)	421	136	274	74	78
	Exclusion and Monitoring Zone Distances (feet)	2,148	1,423		400	
	Piers E7–E8 Measured Distances (feet)	245	79	172	52	59

Source: Compiled by AECOM in 2017

Table 4-11. Measured Distances to Underwater Blasting Threshold Criteria Compared to Estimated Distances and Implemented Exclusion and Monitoring Zones for Implosion of Pier E6

Species Group		Behavioral (Monitoring Zone)	TTS (Monitoring Zone)		PTS (Exclusion Zone)	
Mid-Frequency Cetaceans (dolphins)	Threshold	165 dB cSEL	224 dB Peak	170 dB cSEL	230 dB Peak	185 dB cSEL
	Pier E6 Estimated Distances (feet)	1,330	180	881	98	256
	Exclusion and Monitoring Zone Distances (feet)	2,664	1,781		532	
	Pier E6 Measured Distances (feet)	473	93	332	62	115
High-Frequency Cetaceans (porpoises)	Threshold	135 dB cSEL	196 dB peak	140 dB cSEL	202 dB peak	155 dB cSEL
	Pier E6 Estimated Distances (feet)	12,567	3,127	8,358	1,697	2,459
	Exclusion and Monitoring Zone Distances (feet)	15,080	10,030		2,951	
	Pier E6 Measured Distances (feet)	3,467	637	2,436	422	845
Phocid Pinnipeds (seals)	Threshold	165 dB cSEL	212 dB peak	170 dB cSEL	218 dB peak	185 dB cSEL
	Pier E6 Estimated Distances (feet)	2,220	613	1,484	332	443
	Exclusion and Monitoring Zone Distances (feet)	2,664	1,781		532	
	Pier E6 Measured Distances (feet)	846	212	593	141	204
Otariid Pinnipeds (sea lions)	Threshold	183 dB cSEL	226 dB peak	188 dB cSEL	232 dB peak	203 dB cSEL
	Pier E6 Estimated Distances (feet)	554	147	367	80	106
	Exclusion and Monitoring Zone Distances (feet)	2,664	1,781		532	
	Pier E6 Measured Distances (feet)	230	81	161	54	55

Source: Compiled by AECOM in 2017

Table 4-12. Measured Distances to Underwater Blasting Threshold Criteria Compared to Estimated Distances and Implemented Exclusion and Monitoring Zones for Implosion of Piers E9 and E10

Species Group		Behavioral	TTS		PTS	
Mid-Frequency Cetaceans (dolphins)	Threshold	165 dB cSEL	224 dB peak	170 dB cSEL	230 dB peak	185 dB cSEL
	Two 504-foot-span Pier Estimated Distances (feet)	1,055	166	685	90	190
	Exclusion and Monitoring Zones (feet)	2,148	1,423		400	
	Piers E9–E10 Measured Distances (feet)	918	**199**	645	**132**	**224**
High-Frequency Cetaceans (porpoises)	Threshold	135 dB cSEL	196 dB peak	140 dB cSEL	202 dB peak	155 dB cSEL
	Two 504-foot-span Pier Estimated Distance (feet)	10,300	2,882	6,800	1,564	1,966
	Exclusion and Monitoring Zones (feet)	12,360	8,160		2,359	
	Piers E9–E10 Measured Distances (feet)	6,730	1,364	4,729	904	1,641
Phocid Pinnipeds (seals)	Threshold	165 dB cSEL	212 dB peak	170 dB cSEL	218 dB peak	185 dB cSEL
	Two 504-foot-span Pier Estimated Distances (feet)	1,790	565	1,186	306	333
	Exclusion and Monitoring Zone Distances (feet)	2,148	1,423		400	
	Piers E9–E10 Measured Distances (feet)	1,660	455	1,164	301	**<u>401</u>**
Otariid Pinnipeds (sea lions)	Threshold	183 dB cSEL	226 dB peak	188 dB cSEL	232 dB peak	203 dB cSEL
	Two 504-foot-span Pier Estimated Distances (feet)	421	136	274	74	78
	Exclusion and Monitoring Zone Distances (feet)	2,148	1,423		400	
	Piers E9–E10 Measured Distances (feet)	**455**	**174**	**319**	**115**	**110**

Source: Compiled by AECOM in 2017
Note:
Instances where measured distances exceeded estimated distances, values are shown in **bold**.
Instances where measured distances exceeded implemented exclusion and monitoring zone distances, values are shown in **<u>bold and underlined</u>**..

Table 4-13. Measured Distances to Underwater Blasting Threshold Criteria Compared to Estimated Distances and Implemented Exclusion and Monitoring Zones for Implosion of Piers E11, E12 and E13

Species Group		Behavioral	TTS		PTS	
Mid-Frequency Cetaceans (dolphins)	Threshold	165 dB cSEL	224 dB peak	170 dB cSEL	230 dB peak	185 dB cSEL
	Three 288-foot-span Pier Estimated Distances (feet)	920	166	588	90	132
	Exclusion and Monitoring Zones (feet)	1,896	1,254		367	
	Piers E11–E13 Measured Distances (feet)	**1,200**	**212**	**843**	**141**	**292**
High-Frequency Cetaceans (porpoises)	Threshold	135 dB cSEL	196 dB peak	140 dB cSEL	202 dB peak	155 dB cSEL
	Three 288-foot-span Pier Estimated Distance (feet)	9,403	2,882	5,900	1,564	1,722
	Exclusion and Monitoring Zones (feet)	11,284	7,080		2,066	
	Piers E11–E13 Measured Distances (feet)	8,801	1,451	6,184	961	<u>**2,146**</u>
Phocid Pinnipeds (seals)	Threshold	165 dB cSEL	212 dB peak	170 dB cSEL	218 dB peak	185 dB cSEL
	Three 288-foot-span Pier Estimated Distances (feet)	1,580	565	1,045	306	258
	Exclusion and Monitoring Zone Distances (feet)	1,896	1,254		367	
	Piers E11–E13 Measured Distances (feet)	<u>**2,144**</u>	484	<u>**1,503**</u>	**320**	<u>**518**</u>
Otariid Pinnipeds (sea Lions)	Threshold	183 dB cSEL	226 dB peak	188 dB cSEL	232 dB peak	203 dB cSEL
	Three 288-foot-span Pier Estimated Distances (feet)	339	136	201	74	52
	Exclusion and Monitoring Zone Distances (feet)	1,896	1,254		367	
	Piers E11–E13 Measured Distances (feet)	**588**	**185**	**412**	**122**	**142**

Source: Compiled by AECOM in 2017
Note:
Instances where measured distances exceeded estimated distances, values are shown in **bold**.
Instances where measured distances exceeded implemented exclusion and monitoring zone distances, values are shown in <u>**bold and underlined.**</u>

Table 4-14. Measured Distances to Underwater Blasting Threshold Criteria Compared to Estimated Distances and Implemented Exclusion and Monitoring Zones for Implosion of Piers E14, E15, and E16

Species Group		Behavioral	TTS		PTS	
Mid-Frequency Cetaceans (dolphins)	Threshold	165 dB cSEL	224 dB peak	170 dB cSEL	230 dB peak	185 dB cSEL
	Three 288-foot-span Pier Estimated Distances (feet)	920	166	588	90	132
	Exclusion and Monitoring Zones (feet)	1,896	1,254		367	
	Piers E14–E16 Measured Distances (feet)	**1,028**	**189**	**722**	**125**	**250**
High-Frequency Cetaceans (porpoises)	Threshold	135 dB cSEL	196 dB peak	140 dB cSEL	202 dB peak	155 dB cSEL
	Three 288-foot-span Pier Estimated Distance (feet)	9,403	2,882	5,900	1,564	1,722
	Exclusion and Monitoring Zones (feet)	11,284	7,080		2,066	
	Piers E14–E16 Measured Distances (feet)	7,482	1,291	5,257	855	**1,824**
Phocid Pinnipeds (seals)	Threshold	165 dB cSEL	212 dB peak	170 dB cSEL	218 dB peak	185 dB cSEL
	Three 288-foot-span Pier Estimated Distances (feet)	1,580	565	1,045	306	258
	Exclusion and Monitoring Zone Distances (feet)	1,896	1,254		367	
	Piers E14–E16 Measured Distances (feet)	**1,834**	430	<u>**1,286**</u>	285	<u>**443**</u>
Otariid Pinnipeds (sea lions)	Threshold	183 dB cSEL	226 dB peak	188 dB cSEL	232 dB peak	203 dB cSEL
	Three 288-foot-span Pier Estimated Distances (feet)	339	136	201	74	52
	Exclusion and Monitoring Zone Distances (feet)	1,896	1,254		367	
	Piers E14–E16 Measured Distances (feet)	**503**	**165**	**352**	**109**	**121**

Source: Compiled by AECOM in 2017
Note:
Instances where measured distances exceeded estimated distances, values are shown in **bold**.
Instances where measured distances exceeded implemented exclusion and monitoring zone distances, values are shown in <u>**bold and underlined**</u>**.**
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Table 4-15. Measured Distances to Underwater Blasting Threshold Criteria Compared to Estimated Distances and Implemented Exclusion and Monitoring Zones for Implosion of Piers E17 and E18

Species Group		Behavioral	TTS		PTS	
Mid-Frequency Cetaceans (dolphins)	Threshold	165 dB cSEL	224 dB peak	170 dB cSEL	230 dB peak	185 dB cSEL
	Two 288-foot-span Pier Estimated Distances (feet)	798	166	517	90	126
	Exclusion and Monitoring Zones (feet)	1,631	1,080		367	
	Piers E17–E18 Measured Distances (feet)	511	134	359	89	124
High-Frequency Cetaceans (porpoises)	Threshold	135 dB cSEL	196 dB peak	140 dB cSEL	202 dB peak	155 dB cSEL
	Two 288-foot-span Pier Estimated Distance (feet)	7,700	2,882	5,140	1,564	1,493
	Exclusion and Monitoring Zones (feet)	9,240	6,168		1,877	
	Piers E17–E18 Measured Distances (feet)	3,747	916	2,633	607	913
Phocid Pinnipeds (seals)	Threshold	165 dB cSEL	212 dB peak	170 dB cSEL	218 dB peak	185 dB cSEL
	Two 288-foot-span Pier Estimated Distances (feet)	1,359	565	900	306	232
	Exclusion and Monitoring Zone Distances (feet)	1,631	1,080		367	
	Piers E17–E18 Measured Distances (feet)	914	305	641	202	221
Otariid Pinnipeds (sea lions)	Threshold	183 dB cSEL	226 dB peak	188 dB cSEL	232 dB peak	203 dB cSEL
	Two 288-foot-span Pier Estimated Distances (feet)	304	136	185	74	51
	Exclusion and Monitoring Zone Distances (feet)	1,631	1,080		367	
	Piers E17–E18 Measured Distances (feet)	249	117	174	77	60

Source: Compiled by AECOM in 2017

As summarized in the tables above, incidents occurred where the estimated threshold distances were exceeded. In these cases, the number of Level A behaviors and Level B behaviors would be adjusted. During the last blast event (Piers E17 and E18), one harbor seal was observed immediately after the implosion, just within the exclusion zone (367-foot [111-meter] zone), approximately 300 feet (91 meters) from the pier being imploded. Although this would have been considered a Level A PTS take according to conservatively implemented monitoring zones, the measured hydroacoustic results for the Level A PTS threshold recorded the actual distances at 202 feet (61.5 meters) for the peak threshold and 212 feet (64.6 meters) for the cSEL threshold. Based on the measured results, the harbor seal was technically outside the physical impact zone. The harbor seal was monitored after the blast and did not exhibit any obvious behavioral changes and immediately dove after being sighted.. No stranded animals or animals exhibiting abnormal behavior consistent with PTS impacts were observed during the subsequent stranding surveys for this blast event. Therefore, this harbor seal was not counted as a Level A PTS take.

For the instances when the Level B behavioral or TTS threshold distances were exceeded based on measured results, these take numbers were adjusted accordingly based on measured results as changes in behavior or TTS impacts are harder to discern in the field because they are considered only slight harassment. The level of take was adjusted based on the distance of the animal from the pier being imploded and how it related to the measured distance.

4.4. Conclusions

Marine mammal observers were present for each of the blasts to carefully monitor marine mammal species, before, during, and after each implosion event. Monitoring began at least 30 minutes before, and ended 60 minutes after each event. No animals were found dead, injured, or were reported to be stranded in relation to implosion events. A summary of authorized and total Level B Harassment marine mammal take for all 2017 implosions is shown in Tables 4-16a and 4-16b.

Table 4-16a. Summary of Level B TTS Harassment Take for 2017 Implosions Events

Pier Implosion	TTS (Monitoring Zone)					
	HASE	CASL	HAPO	BODO	NOFS	NOES
E7, E8	1	0	0	0	0	0
E6	12	0	3	0	0	0
E9, E10	3	0	0	0	0	0

E11, E12, E13	2	0	0	0	0	0
E14, E15, E16	0	0	0	0	0	0
E17, E18	1	0	0	0	0	0
Total Take Authorized	48	12	9	3	3	3
Total Take Observed	19	0	3	0	0	0

Notes:

Take numbers were tallied according to the measured hydroacoustic distances, as shown in Tables 4-10 through 4-15. Although measured threshold distances exceeded estimated threshold distances in some instances, no Level A take was observed, and the observed Level B harassment take numbers did not exceed authorized limits.

Species Codes:

HASE = harbor seal; CASL = California sea lion; HAPO = harbor porpoise; BODO = bottlenose dolphin; NOFS = northern fur seal; NOES = northern elephant seal

Table 4-16b. Summary of Level B Behavioral Harassment Take for 2017 Implosions Events

	Behavioral (Monitoring Zone)					
Pier Implosion	**HASE**	**CASL**	**HAPO**	**BODO**	**NOFS**	**NOES**
E7, E8	5	0	0	0	0	0
E6	0	0	0	0	0	0
E9, E10	0	0	0	0	0	0
E11, E12, E13	3	0	0	0	0	0
E14, E15, E16	0	0	0	0	0	0
E17, E18	1	0	0	0	0	0
Total Take Authorized	66	18	18	6	6	6
Total Take Observed	9	0	0	0	0	0

Notes:

Take numbers were tallied according to the measured hydroacoustic distances, as shown in Tables 4-10 through 4-15. Although measured threshold distances exceeded estimated threshold distances in some instances, no Level A take was observed, and the observed Level B harassment take numbers did not exceed authorized limits.

Species Codes:

HASE = harbor seal; CASL = California sea lion; HAPO = harbor porpoise; BODO = bottlenose dolphin; NOFS = northern fur seal; NOES = northern elephant seal

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Chapter 5. Avian Monitoring

5.1. Monitoring Methods

The Department's avian monitoring program for tests blasts and controlled blasting was designed to ensure that protected avian species would not be affected by harmful sound and pressure waves, generated using explosive charges in the Bay. Because of the impedance of sound at the air–water interface, impacts on birds would be limited to any individuals submerged during an implosion. The following sections describe the monitoring protocol and monitoring results of the Department's avian monitoring program for the test blast and implosions associated with removal of Piers E6 through E18. The Department implemented specific measures, as required by CDFW Incidental Take Permit No. 2081-2001-021-03, USFWS Biological Opinion No. 1-1-02-F-0002, and BCDC Permit No. 2001.008.32 (formerly Permit No. 8-01), to minimize impacts on special-status diving bird species known to occur in the SFOBB project area. Special-status diving bird species that were evaluated included FESA and California Endangered Species Act (CESA) listed species, and California Fish and Game Code (CFGC) fully protected species. The special-status diving bird species were the California least tern (*Sterna antillarum browni*; CESA/FESA endangered, CFGC fully protected) and the California brown pelican (*Pelecanus occidentalis californicus*; CFGC fully protected).

The following sections describe the various elements of avian monitoring that was completed before and during all implosions associated with removal of Piers E6 through E18. Monitoring for bird predation after the implosions is discussed in Chapter 8.

5.1.1. Establishment of the Avian Watch Zone

In 2012, the Washington Department of Transportation established a guidance threshold of 202 dB cSEL for auditory injury and 208 dB cSEL for non-auditory injury thresholds during in-water pile driving for marbled murrelets (WSDOT 2014). This threshold is not a regulatory requirement but is a conservative guideline that the Department elected to adopt. The Department proceeded with the use of the auditory injury threshold (i.e., 202 dB cSEL) to avoid impacts on protected diving birds during the Piers E3, E4, and E5 implosions, and to maintain consistency with past projects where measures were taken to protect avian species. For the implosion of Pier E3, the Department calculated a 500-foot (152-meter) distance to the 202 dB cSEL threshold, determined by advanced modeling. Based on the Pier E3 Demonstration Project's hydroacoustic monitoring results, the 202 dB cSEL threshold was measured at approximately 300 feet (91 meters). Based on these results, the Department established a 300-foot watch zone around Piers E4 and E5.

The measured cSEL levels observed during Piers E4 and E5 were 201 and 137 feet (61 and 41 meters), respectively. These results indicated that the Department's calculated distance for potential auditory injury to birds was conservative and slightly higher than the measured cSEL levels. The Department established a 300-foot avian watch zone for the implosion of Pier E6 and a 200-foot watch zone for Piers E7 through E18, to protect diving birds during each controlled blasting event.

5.1.2. **Avian Deterrents**

Auditory and visual deterrents also were available and used as necessary to encourage target avian species to relocate from the 300-foot watch zone before the test blasts and implosion associated with removal of Pier E6 and the 200-foot watch zone for blast events for Piers E7 through E18. The Department used up to four sound cannons (fired remotely) to discourage birds from occupying the avian watch zone before the test blasts and pier implosion. The propane-powered sound cannons emit a short, loud shot. The sound cannons were used as an avian deterrent during the Piers E6 through E18 implosions because they were observed to successfully flush birds during the Pier E3 Demonstration Project and the Piers E4 and E5 implosions. During each blast event for Piers E6 through E18, at least two of the four cannons were fired successfully.

The Department received USFWS Depredation Permit MB57490C-0, and a UAV was used to deter and harass non-listed birds as a pre-blast deterrent. The UAV was deployed on the day of the dry run on September 1, 2017, and again for pre-blast deterrence on September 30, October 14, and October 28.

5.1.3. **Avian Monitoring**

Three to four monitors were present to monitor the avian watch zone for bird activity before the implosions of Piers E6 through E18. One monitor was designated as the Lead Avian Monitor, who communicated directly with the Department's Environmental Compliance Manager or designee. At least two of the avian monitors were on the bicycle and pedestrian pathway of the new east span and one to two additional avian monitor(s) were on either the footing of a marine foundation of the new east span, on a maintenance platform under the new east span, or were at the OTD before, during, and after the implosion. Each avian monitor had an assigned "Avian Watch Zone" where they conducted their observations (Figures 5-1 through 5-6). Based on the position of each monitor, they were able to cover potential blind spots of the other monitors. In addition, the monitor located on the marine foundation or maintenance platform below the new span was able to observe bird activity that monitors on the bike path could not see.

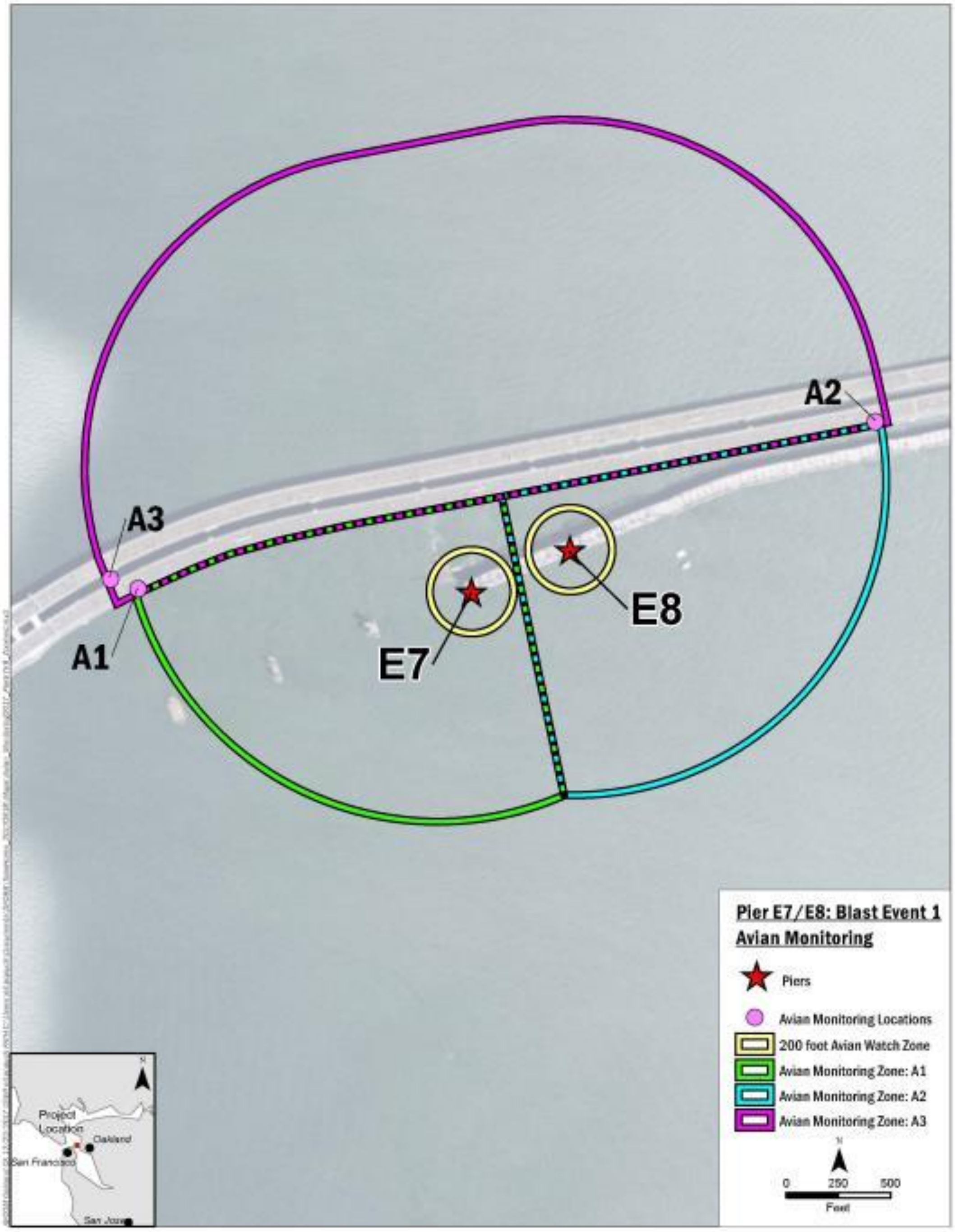

Figure 5-1. Avian Monitoring Locations and Avian Watch Zones for Piers E7 and E8 Blast Event

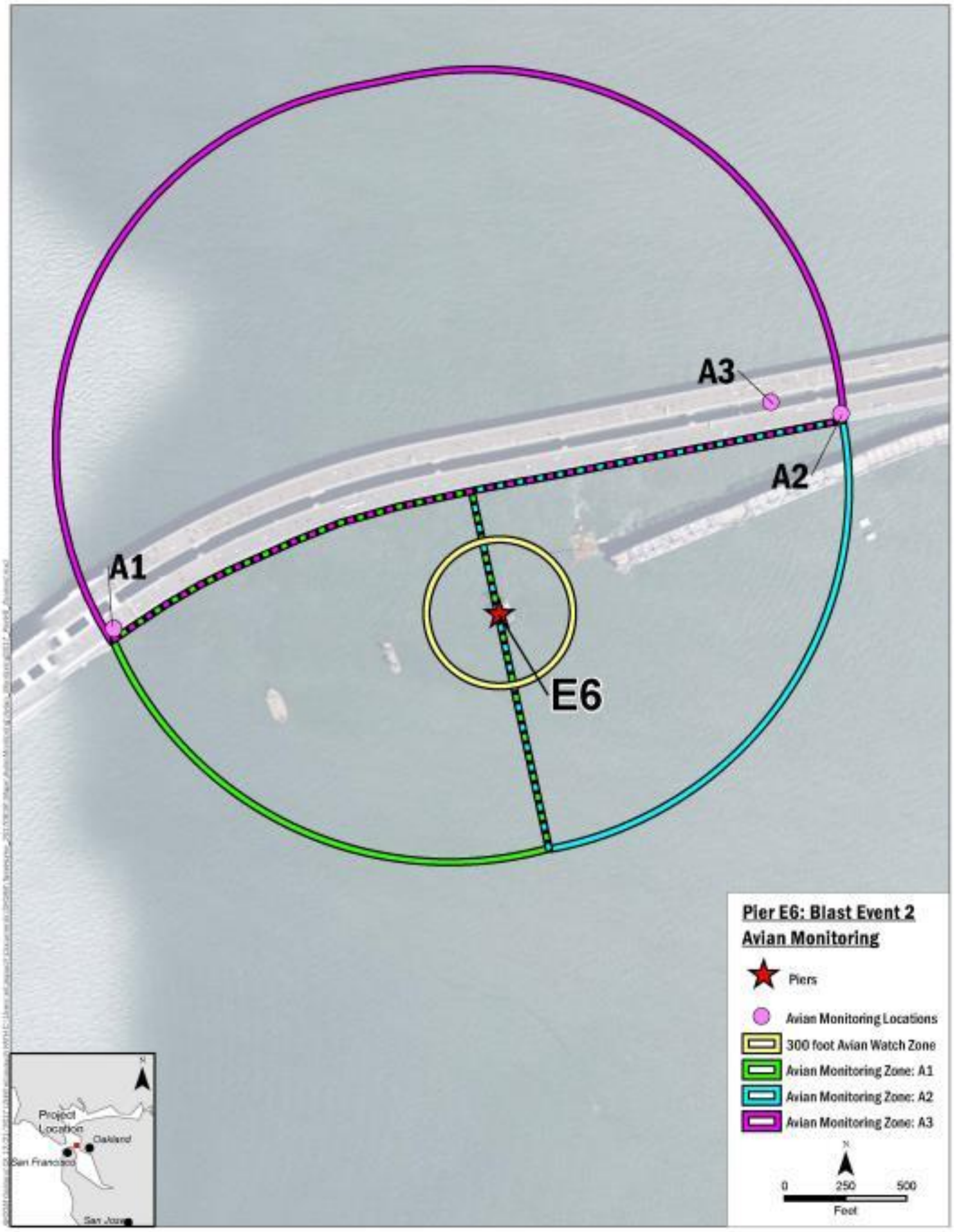

Figure 5-2. Avian Monitoring Locations and Avian Watch Zones for Pier E6 Blast Event

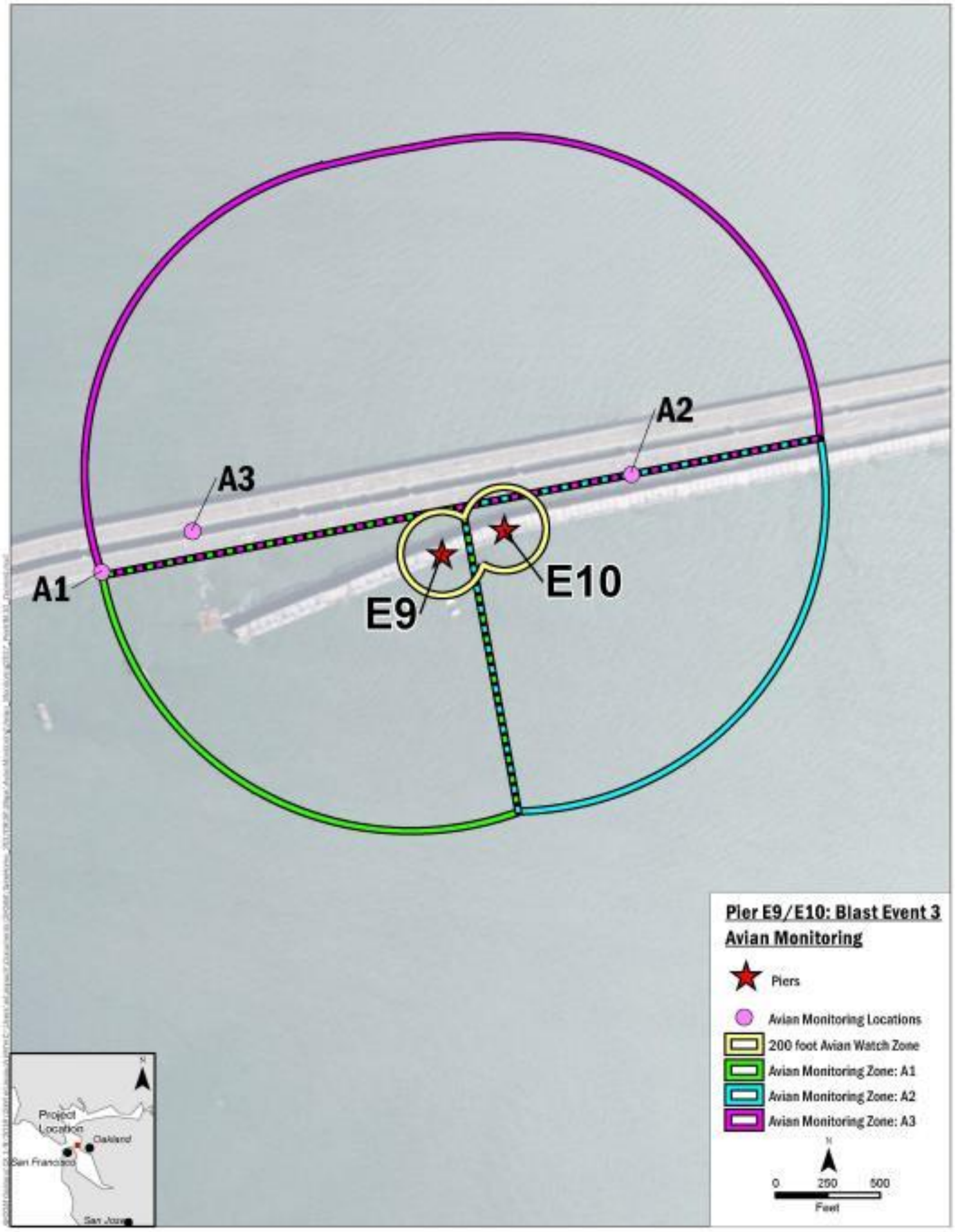

Figure 5-3. Avian Monitoring Locations and Avian Watch Zones for Piers E9 and E10 Blast Event

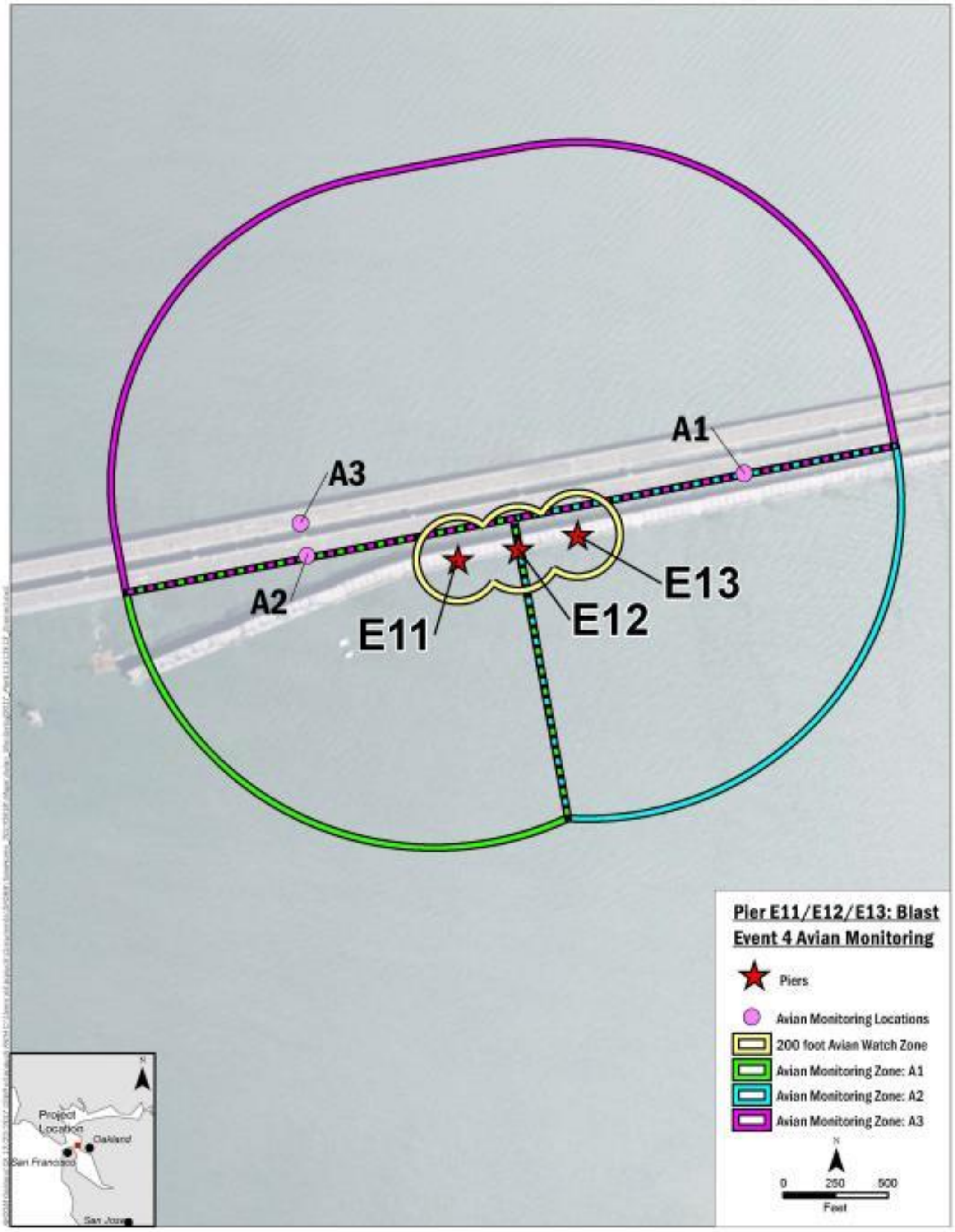

Figure 5-4. Avian Monitoring Locations and Avian Watch Zones for Piers E11, E12, and E13 Blast Event

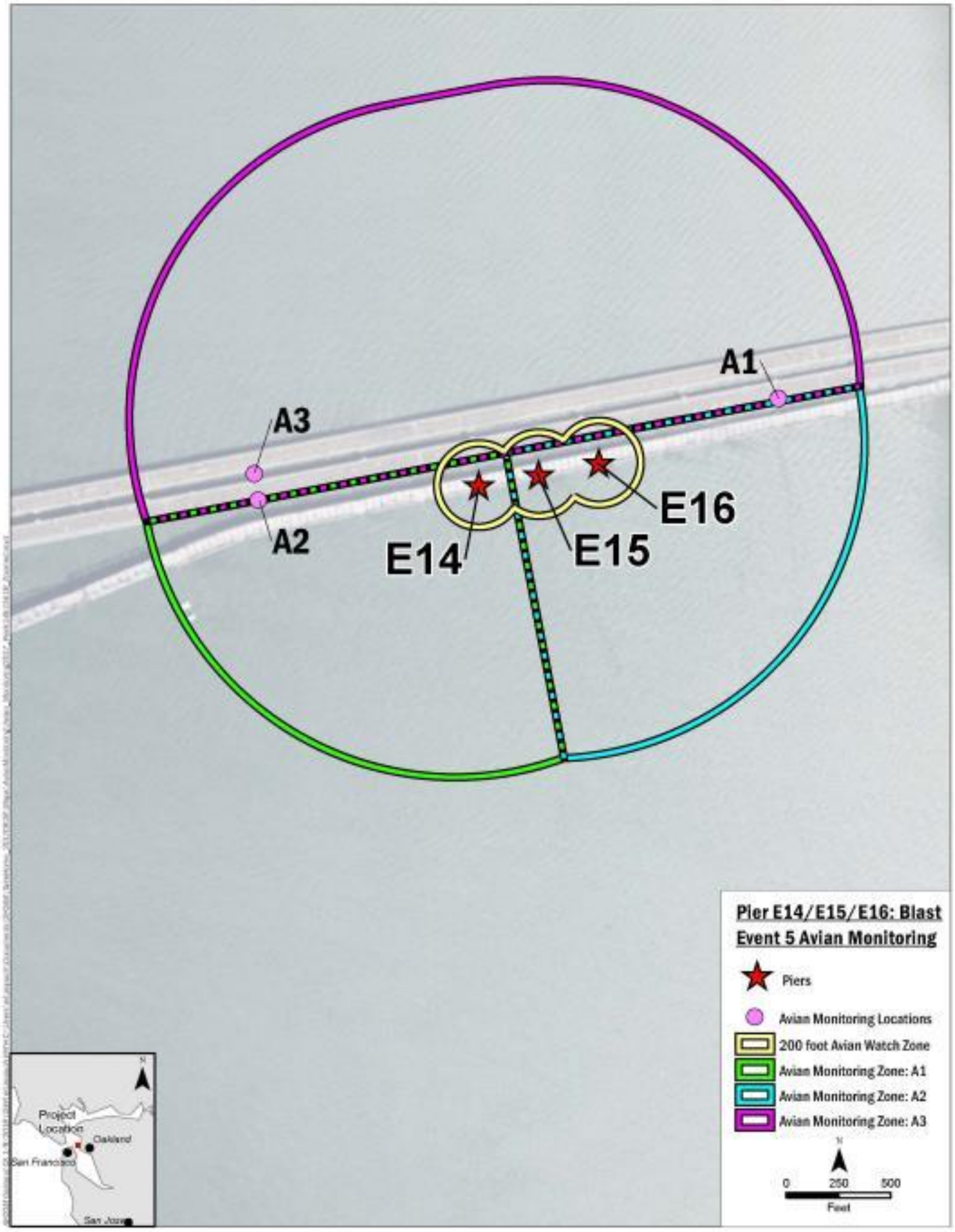

Figure 5-5. Avian Monitoring Locations and Avian Watch Zones for Piers E14, E15, and E16 Blast Event

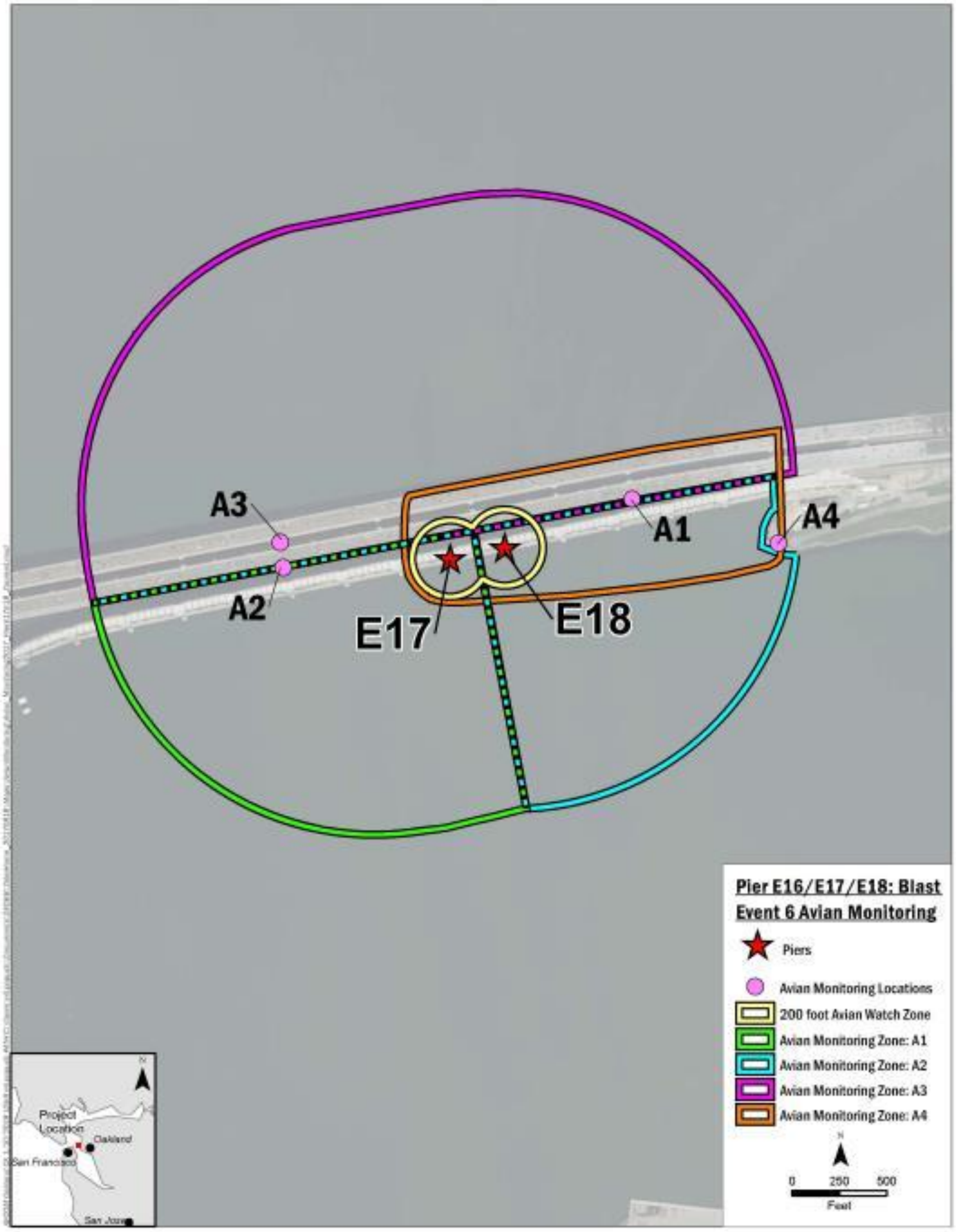

Figure 5-6. Avian Monitoring Locations and Avian Watch Zones for Piers E17 and E18 Blast Event

The avian monitors observed and recorded all bird activity within and surrounding the avian watch zone before the blast. At a minimum, the following data were recorded for each bird observed in the time leading up to the implosion:

- time;
- species;
- approximate distance from pier;
- cardinal direction relative to pier; and
- behavior/status (i.e., flying through, foraging from the air, on water, diving, foraging below surface).

When a protected (e.g., FESA, CESA, or CFGC-fully protected) bird was sighted, the avian monitors observed and recorded its activity. If the bird was in the air and traveling from the avian watch zone, no further action was necessary. If a bird was sighted diving into or foraging in the water column within the watch zone, the monitor communicated this information to the Lead Avian Monitor, who was in communication with the Department’s Environmental Manager or his designee, Resident Engineer, and Blaster-in-Charge. If a protected species was observed diving in the avian watch zone before the pier implosion(s), the implosion(s) were to be delayed until the protected species was no longer submerged in the water column within the watch zone. However, no protected species were observed immediately before the Piers E6 through E18 blast events.

If a dead or injured bird was sighted after the blast events, the Lead Avian Monitor was to notify the Department’s Environmental Manager, who was to contact USFWS and CDFW within 24 hours. The Department notified International Bird Rescue (IBR) of the implosions dates set for Piers E6 through E18 blasts, so that IBR could make preparatory receiving arrangements in the case of any dead on injured birds. No dead or injured birds were observed after the Pier E6 through E18 blast events.

5.2. Monitoring Summary and Results

5.2.1. Piers E7 and E8

On September 2, 2017, four Department avian monitors were in position by 8 a.m. to monitor birds in the vicinity of the piers before and during the implosion of Piers E7 and E8. Three monitors were in two locations on the new SFOBB east span bike path, approximately 150 feet (45 meters) above water level; the Avian Monitoring Lead was approximately 1,000 feet (304 meters) northwest of Pier E7 (A1) and two avian monitors were approximately 1,000 feet (304 meters) northeast of Pier E8 (A2). A fourth monitor was beneath the skyway on the footing of Pier E3 of the new SFOBB east span (A3), near the water level and approximately 1,300 feet (396 meters) northwest of Pier E7 (Figure 5-1). The weather was hot, with temperatures in the mid-80 degrees Fahrenheit at the time of the blast, and wind speeds of 6.3 miles per hour (mph) before the blast and 2.4 mph following the blast. Visibility was good, but somewhat hazy conditions existed because of a thermal inversion and fires in the region.

In the hour and a half leading up to the blast, extensive bird activity was noted in the vicinity of Piers E7 and E8. Species observed by avian monitors during the monitoring period before the blast included double-crested cormorant (*Phalacrocorax auritus*), California brown pelican, pied-billed grebe (*Podilymbus podiceps*), western gull (*Larus occidentalis*), and other unidentified gulls (*Larus* spp.). Seven sightings of California brown pelican flying over the work area were recorded by avian monitors before 9:30 a.m. (from A1, A2, and A3). The avian monitor on Pier E3 of the new east span (A3) also reported two sightings of pied-billed grebe swimming at 500 and 1,000 feet (152 and 304 meters) from Pier E7, at 9:30 and 10:35 a.m., respectively.

The predominant species in the work area were double-crested cormorant and western gull. Double-crested cormorants were observed flying over the work area, swimming in the water inside and outside the debris booms that were anchored approximately 150 feet (45 meters) around each pier, roosting on Pier E6 west of Pier E7, roosting on Piers E9, E10, and E11 east of Pier E8, roosting on ropes anchoring equipment and barges, and roosting on the telecom huts approximately 500 feet (152 meters) southeast of Pier E8. The high level of double-crested cormorant activity likely was attributable to the nearby cormorant breeding colony, residing on the nesting platforms between Piers E8 and E10 of the new east span during the 2017 nesting season. Double-crested cormorant was frequently observed flying between these platforms and the various locations previously noted.

Gulls also were observed flying over and swimming around the work area, roosting on barges staged east and west of Piers E7 and E8, and roosting on Piers E7 and E8. Between two to four gulls were observed roosting on Piers E7 and E8 before the blast. The contractor made several unsuccessful attempts to flush these birds with propane sound cannons, firing the cannons approximately 10 to15 times. After the unsuccessful attempts with the sound cannons, the western gulls were flushed successfully from both piers 7 minutes before the blast, using a UAV operated by the project team.

No California least tern or California brown pelican was observed within the 200-foot (61-meter) avian watch zones around Piers E7 and E8 before the blast.

At the time of the blast at 10:36 a.m., a western gull and double-crested cormorant were roosting approximately 150 feet (45 meters) from Pier E8. The double-crested cormorant was roosting on a rope anchoring the debris boom north of Pier E8, and the western gull was roosting on a barge staged east of Pier E8. Both birds appeared to be unharmed by the blast, and no injured birds were observed by avian monitors following the blast.

5.2.2. **Pier E6**

On September 16, 2017, four of the Department's avian monitors were in position by 8:30 a.m. to monitor birds in the vicinity before and during the implosion of Pier E6. Three monitors were in two locations on the new SFOBB east span bike path, approximately 150 feet (45 meters) above water level; the Avian Monitoring Lead was approximately 1,000 feet (304 meters) northwest of Pier E6 (A1) and two avian monitors were approximately 1,000 feet (304 meters) northeast of Pier E6 (A2). A fourth monitor was on a maintenance platform on the underside of the westbound skyway of the new SFOBB east span (A3), approximately 1,300 feet (396 meters) northeast of Pier E6 (Figure 5-2). The weather was warm, with temperatures in high 60s at the time of the blast. Visibility was good with clear skies.

In the hour and a half leading up to the blast, limited bird activity was noted in the vicinity of Pier E6. Species observed by avian monitors during the monitoring period before the blast included double-crested cormorant, California brown pelican, pied-billed grebe, rock dove (*Columba livia*), osprey (*Pandion haliaetus*), western gull, and other unidentified gulls. Two sightings of California brown pelican flying over the project area were recorded by avian monitors at approximately 9:30 and 9:40 a.m. from positions A1, A2, and A3). The avian monitor at position A3 also had one sighting of pied-billed grebe swimming 800 feet (243 meters) from Pier E8 of the new bridge at 9:40 a.m. The biologist at position A1 observed an osprey transiting the area towards Oakland Harbor at 9:13 a.m. Double-crested cormorants were mostly observed perched on or swimming near the fiber optic structures located approximately 1,500 feet (457 meters) east of Pier E6. The most predominant species in the work area were gulls flying over and swimming around the work area, and roosting on barges staged east and west of Pier E6. No gulls were observed perching on Pier E6 throughout the morning. The sound cannons were fired immediately before the blast to flush any undetected birds; however, none appear to have flushed. No California least terns or California brown pelicans were observed within the 300-foot avian watch zones around Pier E6 immediately before the blast. At the time of the blast at 10 a.m., one western gull was perched on the adjacent barges but appeared to be unharmed by the implosion.

5.2.3. **Piers E9 and E10**

On September 30, 2017, three Department avian monitors were in position by 7:40 a.m. to monitor birds in the vicinity of the piers before and during the implosion of Piers E9 and E10. Two monitors were in two locations on the new SFOBB east span bike path, approximately 150 feet (45 meters) above water level; the Avian Monitoring Lead was approximately 1,100 feet (335 meters) northwest of Pier E9 (position A1) and the other avian monitor was approximately 660 feet (201 meters) northeast of Pier E10 (position A2). A third monitor was beneath the skyway on the footing of Pier E6 of the new SFOBB east span (position A3), near the water level and approximately 1,200 feet (365 meters) northwest of Pier E9 (Figure 5-3). The weather was cool, with temperatures in the mid-60 degrees Fahrenheit at the time of the blast and average wind speeds of 4.3 mph before the blast. Visibility was good, although the glare from the morning sun obscured visibility when viewing the piers from the west.

In the hour and a half leading up to the blast, extensive bird activity was noted in the vicinity of Piers E9 and E10. Species observed by avian monitors during the monitoring period before the blast included double-crested cormorant, California brown pelican, pied-billed grebe, Canada goose, western gull, and other unidentified gulls. Six California brown pelicans were observed flying over the work area before the blast. Also, two brown pelicans landed on Pier E11 at 8:20 a.m., perched on the pier for several minutes, and then flushed and left the project area. The most predominant birds in the project area were double-crested cormorants and gulls. Double-crested cormorants were observed flying over the project area, swimming in the water outside the debris booms that were anchored approximately 100 feet (30 meters) around each pier, roosting on piers of the original east span east of Pier E10, and roosting on the telecom huts approximately 200 feet (60 meters) south of Pier E9. The high level of double-crested cormorant activity likely was attributable to the nearby cormorant breeding colony, residing on the nesting platforms between Piers E8 and E10 of the new east span during the 2017 nesting season. Double-crested cormorants frequently were observed flying between these platforms and the various locations previously noted. Gulls also were observed flying over and swimming around the project area, and roosting on barges staged east, west, and between Piers E9 and E10. One gull landed on Pier E10 at 9:13 a.m., and the contractor made an attempt to flush the bird with propane-generated sound cannons, but a malfunction occurred and the cannons did not fire. In response to the unsuccessful attempt to fire the sound cannons, the Department's contractor dispatched a UAV to flush the gull on

Pier E10; the gull flushed at 9:15 a.m., before the UAV reached Pier E10. At the time of the blast at 9:23 a.m., two western gulls were roosting on the contractor's barge, approximately 100 feet (30 meters) between Piers E9 and E10. The birds flushed when the blast occurred and appeared to be unharmed by the blast. No injured birds were observed by the avian monitors, following the blast.

5.2.4. Piers E11, E12, and E13

On October 14, 2017, three Department avian monitors were in position by 7:30 a.m. to monitor birds in the vicinity before and during the implosion of Piers E11 through E13. Two monitors were in different locations on the new SFOBB east span bike path, approximately 150 feet (35 meters) above water level; the Avian Monitoring Lead was approximately 875 feet (266 meters) northeast of Pier E13 (position A1) and the other avian monitor was approximately 875 feet (266 meters) northwest of Pier E11 (position A2). A third monitor was beneath the skyway on the footing of Pier E8 of the new SFOBB east span (position A3), near the water level and approximately 1,100 feet (335 meters) northwest of Pier E11 (Figure 5-4). The weather was cool, with temperatures in the mid-60 degrees Fahrenheit at the time of the blast and average wind speeds of 2.9 mph before the blast. Visibility was good, although the glare from the morning sun partially obscured visibility when viewing the piers from the west at certain times of the morning.

In the hour and a half leading up to the blast, bird activity was focused on and around the contractor barges adjacent to Piers E11 through E13, as well as on the cable crossing structures 630 feet (192 meters) southwest of Pier E11. Species observed by avian monitors during the monitoring period before the blast included double-crested cormorant, California brown pelican, western gull, and other unidentified gulls. Several California brown pelicans were observed congregating near the cable crossing structures, as well as flying through the area. The most common species in the project area were gulls, which perched in various places, including on the barge spud piles, air compressors, other barge structures, and Piers E11 through E13. Double-crested cormorants were less prevalent than in the previous blast events, although one was observed swimming in the bubble curtain area (and subsequently was flushed) before the blast. The decrease in double-crested cormorant activity relative to recent events likely was because of young-of-the-year fledglings leaving their nests on the underside of the SFOBB new span. Before the blast, a number of gulls were on the pier caps of Piers E11 and E12. At 8:46 a.m., the sound cannons were fired and the birds on those piers were flushed successfully. At this time, a UAV operated by the contractor also was used to flush birds from the piers and barges. The sound cannons were fired again at 8:48 and 8:49 a.m., flushing additional birds from the adjacent barges. At the time of the blast at

8:51 a.m., gulls were roosting on the contractor's barges, approximately 100 feet (30 meters) between the piers. The birds flushed when the blast occurred and appeared to be unharmed by the blast. No injured birds were observed by the avian monitors following the blast.

5.2.5. Piers E14, E15, and E16

On October 28, 2017, three Department avian monitors were in position by 7 a.m. to monitor birds in the vicinity before and during the implosion of Piers E14 through E16. Two monitors were in different locations on the new SFOBB east span bike path, approximately 150 feet (35 meters) above water level; the Avian Monitoring Lead was approximately 875 feet (266 meters) northeast of Pier E16 (position A1) and the other avian monitor was approximately 875 feet (266 meters) northwest of Pier E14 (position A2). A third monitor was beneath the roadway on the footing of Pier E9 of the new SFOBB east span (position A3), near the water level and approximately 1,100 feet (335 meters) northwest of Pier E14 (Figure 5-5). The weather was cool, with temperatures in the mid-50 degrees Fahrenheit at the time of the blast and average wind speeds of 3.2 mph before the blast. Visibility was good, although the glare from the morning sun partially obscured visibility when viewing the piers from the west at certain times of the morning.

In the approximately 45 minutes leading up to the blast, bird activity was focused on and around the contractor barges adjacent to Piers E14 through E16. Species observed by the avian monitors during the monitoring period before the blast included double-crested cormorant, American white pelican (*Pelecanus erythrorhynchos*), western gull, and other unidentified gulls. Double-crested cormorants were seen in a large group, leaving the nearby platforms on the new SFOBB east span at the beginning of the monitoring period. American white pelican was observed near the cable crossing structures, west of the piers, approximately 15 minutes before the blast. The most common species in the project area were gulls, which were observed throughout the monitoring period, perched at various places, including on support barge spud piles and nearby pier footings of the old bridge. Immediately before the blast, a number of gulls were on the spuds of the support barges. At 7:46 a.m., the sound cannons were fired and the gulls on the barge spuds were flushed successfully. Before the sound cannons were fired, a UAV operated by the contractor also was used to flush birds from the piers and barges. At the time of the blast at 7:49 a.m., no birds were in the vicinity of the piers being imploded. No injured birds were observed by the avian monitors following the blast.

5.2.6. Piers E17 and E18

On November 11, 2017, four Department avian monitors were in position by 6 a.m. to monitor birds in the vicinity before and during the implosion of Piers E17 and E18. Two monitors were in different locations on the new SFOBB east span bike path, approximately 100 feet (30 meters) above water level; the Avian Monitoring Lead was approximately 860 feet (262 meters) northeast of Pier E18 (position A1) and the other avian monitor was approximately 860 feet (262 meters) northwest of Pier E17 (position A2). A third monitor was beneath the roadway on the footing of Pier E11 of the new SFOBB east span (position A3), near the water level and approximately 920 feet (280 meters) northwest of Pier E17. A fourth monitor was at the OTD (position A4), approximately 1,400 feet (426 meters) southeast of Pier E18 (Figure 5-6). Visibility was good and the weather was cool, with temperatures in the mid-50 degrees Fahrenheit and average wind speeds of 0.8 mph.

In the approximately 90 minutes leading up to the blast, bird activity was focused on and around the contractor barges adjacent to Piers E17 and E18. Species observed by the avian monitors during the monitoring period before the blast included double-crested cormorant, marbled godwit (*Limosa fedoa*), bufflehead (*Bucephala albeola*), sanderling (*Calidris alba*), western gull, and other unidentified gulls. Multiple double-crested cormorants were observed leaving the nearby platforms on the new SFOBB east span and flying south at around 6:28 a.m. The most common species in the project area were gulls, which were observed throughout the monitoring period, perched at various places including on support barge spud piles and nearby pier footings of the old bridge. A gull landed on Pier E17 at 6:31 a.m. and flew off at 6:33 a.m. A marbled godwit was observed on Pier E20 at 6:50 a.m., and a flotilla of seven bufflehead was observed approximately 1,500 feet (457 meters) south of Pier E18 at 7:25 a.m. The sound cannons were fired at 6:50 a.m. and again at 7:25 a.m. At the time of the blast at 7:27 a.m., no birds were in the vicinity of the piers being imploded. No injured birds were observed by the avian monitors following the blast.

5.3. Conclusions

No birds were observed diving in the avian watch zones immediately before any of the blast events, and no birds were observed to be harmed during any of the blast events for Piers E6 through E18. Avian deterrents that were used for each blast event (i.e., UAV and sound cannons) were successful in hazing birds away from the 300-foot (100-meter) watch zone before the test blast and implosion associated with removal of Pier E6 and the 200-foot (61-meter) watch zone for the implosions of Piers E7 through E18. The avian monitors carefully monitored for specific bird species, especially those having special status, before, during, and after each blast event.

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Chapter 6. Fisheries Hydroacoustic Monitoring

6.1. Fish Threshold Criteria

On June 12, 2008, the Fisheries Hydroacoustic Working Group (FHWG)—whose members include NMFS's Southwest and Northwest Divisions; the California, Washington, and Oregon Departments of Transportation; CDFW; and the Federal Highway Administration—issued an agreement for establishment of interim threshold criteria to determine the effects of high-intensity sound on fish. These criteria were established after extensive review of the most recent analysis of the effects of underwater noise on fish from pile driving in water. The agreed-on threshold criteria for noise to have an injury effect on fish was set at 206 dB peak sound pressure level, 187 dB cSEL for fish over 2 grams (0.07 ounce), and 183 dB cSEL for fish less than 2 grams (0.07 ounce) (FHWG 2008). The FHWG determined that noise at or above these levels can cause damage to auditory tissues and temporary threshold shift in fish. Based on hydroacoustics results from the Pier E3 Demonstration Project, the linear distances from the implosion to the limit of the FHWG thresholds and the total projected maximum area potentially affected by the blast events are shown in Table 6-1.

Table 6-1. Radial Distance to Fisheries Hydroacoustic Working Group Regulatory Thresholds, and Area to be Affected from Piers E6 through E18 Implosions

Threshold	Distance (feet [meters])	Predicted Area for Pier E6 through E18 Implosions (acres [square meters])
206 dB peak SPL	1,165 (355)	105.57 (427,211)
187 dB cSEL	889 (271)	63.00 (254,936)
183 dB cSEL	1,230 (375)	117.24 (474,439)
150 dB RMS	4,752 (1,448)	1,477.09 (5,977,572)

Notes:
cSEL = cumulative sound exposure level; dB = decibel; RMS = root-mean-square; SPL = sound pressure level
Sources: Department 2016b; compiled by AECOM in 2016

6.2. Hydroacoustic Monitoring Results

A detailed summary of hydroacoustic monitoring methods and results are provided in Chapter 3 of this report. In the Chapter 3 plots that provide peak and cSEL levels for each implosion event, the corresponding fish criteria (206 dB peak pressure, 187 dB cSEL for fish greater than or equal to 2 grams and 183 dB cSEL for fish less than 2 grams) are shown. Using each of the peak level and cSEL trend lines, distances to exposure levels that were at or greater than the thresholds were calculated. The results of the monitoring related to fish criteria for each blast event in 2017 are shown in Table 6-2.

Table 6-2. Hydroacoustic Monitoring Results for the 2017 Blast Events

Piers	Distance to Criteria/Threshold		
	Peak Pressure 206 dB (feet)	cSEL, ≥ 2 grams 187 dB (feet)	cSEL, < 2 grams 183 dB (feet)
E7 and E8	312	334	450
E6	320	312	421
E9 and E10	687	635	858
E11, E12, and E13	730	839	1,132
E14, E15, and E16	650	711	960
E17 and E18	461	339	457

Notes:

cSEL = cumulative sound exposure level; dB = decibel

Sources: Compiled by AECOM in 2017

Chapter 7. Fish Assemblage Survey

As a condition of the CDFW Incidental Take Permit, major amendment No. 5 (Permit No. 2081 2001 021 03, Section 2[i]), the Department was required to conduct sonar-based surveys before each implosion, to assess the presence of fish assemblages in the waters around the piers. The surveys were intended to identify the presence of any major schools of fish massed in the areas immediately surrounding the piers that could be affected by the blast.

7.1. Survey Methods

Approximately 4 hours before each scheduled blast, a boat occupied by both construction staff and biologists navigated around the piers, using a Lowrance Hook 9 fishfinder/ chartplotter (fish finder sonar device). Because of the presence of safety and navigational hazards in the area, including explosives, delicate hydroacoustic equipment lines, cables, air hoses, and anchor lines, the boat was required to maintain a safe distance of approximately 500 feet (152 meters) from each pier. Because of the configuration of the hazards in the area, each survey generally was divided into four quadrants (i.e., northwest, southwest, northeast, and southeast). During the survey within each quadrant, the biologist took photographs of the fish finder display screen and recorded the GPS coordinates and the time. Any potential schools of fish that were detected also were recorded in the same way. Because of the limitations of the survey methodology, determining whether fish seen during this survey were present during the blast or if they were affected by the blast was not possible.

7.2. Survey Summary and Results

Nearly all of the sonar surveys conducted by boat resulted in the recording of observed targets. Targets displayed on the fish finder sonar device may have indicated the presence of a fish assemblage but were not confirmed as fish assemblages. Fish finder sonar devices also can display targets for wave action, debris, and other anomalies, such as distortion. The sonar surveys provided a view of the general densities of wildlife species that are present during the brief window of the survey; however, the fish and wildlife could not be identified to species-level using sonar. The results of the surveys (i.e., photos and a report memo) were sent to CDFW electronically within 72 hours of the blasts and are provided in Appendix B.

7.2.1. **Piers E7 and E8**

Fish assemblage data around Piers E7 and E8 were recorded at 33 points. Two passes were made at concentric circles of approximately 500 and 750 feet (152 and 228 meters) away from the piers. The survey was conducted from 8:12 to 9:20 a.m. on September 2, 2017, and the implosion occurred at 10:36 a.m.

7.2.2. **Pier E6**

Fish assemblage data around Pier E6 were recorded at 37 points. Two passes were made at concentric circles of approximately 800 and 1,000 feet (243 and 304 meters) away from Pier E6. Images of the fish-finder screen and GPS points were recorded at regular intervals while the boat was piloted around the piers. The survey was conducted from 7:54 to 8:27 a.m. on September 16, 2017, and the implosion occurred at 10 a.m.

7.2.3. **Piers E9 and E10**

Fish assemblage data around Piers E9 and E10 were recorded at 54 points. Two passes were made at concentric circles of approximately 500 and 750 feet (152 and 228 meters) away from the piers to be imploded. The survey was conducted from 7:14 to 8:48 a.m. on September 30, 2017, and the implosion occurred at 9:23 a.m. While performing the sonar survey, very few areas of fish assemblage were noted. The areas of highest fish concentration were approximately 750 feet (228 meters) southeast of the piers.

7.2.4. **Piers E11, E12, and E13**

Fish assemblage data around Piers E11, E12, and E13 were recorded at 53 points. Two passes were made at concentric circles of approximately 500 and 750 feet (152 and 228 meters) away from the piers to be imploded. The survey was conducted from 7:33 to 8:10 a.m. on October 14, 2017, and the implosion occurred at 8:51 a.m. While performing the sonar survey, very few areas of fish assemblage were noted. The areas of highest fish concentration were approximately 500 feet (152 meters) south of the piers.

7.2.5. **Piers E14, E15, and E16**

Fish assemblage data around Piers E14, E15, and E16 were recorded at 54 points. Two passes were made at concentric circles of approximately 500 and 750 feet (152 and 228 meters) away from the piers to be imploded. The survey was conducted from 6:35 to 7:11 a.m. on October 28, 2017, and the implosion occurred at 7:49 a.m. While performing the sonar survey, very few areas of fish assemblage were noted.

7.2.6. **Piers E17 and E18**

Fish assemblage data around Piers E17 and E18 were recorded at 58 points. Two passes were made at concentric circles of approximately 500 and 750 feet (152 and 228 meters) away from the piers to be imploded. The survey was conducted from 5:44 to 6:14 a.m. on November 11, 2017, and the implosion occurred at 7:27 a.m. While performing the sonar survey, very few areas of fish assemblage were noted, with the south and southeast quadrants having the highest concentration of recorded targets.

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Chapter 8. Bird Predation Monitoring

8.1. Monitoring Methods

Bird predation monitoring was conducted immediately after each pier implosion, to help assess the level to which fish were being affected by the project. Bird predation was defined as birds attempting to prey or feed on other organisms. Monitoring of predation activity consisted of counting bird strike attempts on the water surface. A bird strike attempt did not require visual confirmation that the attempt was successful, but was used as a proxy to demonstrate active feeding behavior and general bird activity in response to fish or other debris on the water surface.

Immediately after each implosion, the avian monitors on the bike path of the new SFOBB and the avian monitor(s) on either a maintenance platform on the new SFOBB, a pier footing supporting the new SFOBB, and/or the OTD transitioned to monitor signs of bird strikes on the water's surface around the former pier(s). The debris on the surface immediately following a pier implosion was made up of a mixture of wood debris (from the blast mat), organic material (from the Bay bottom or outside the pier, barnacles, or other invertebrates attached to the pier walls), mud, foam or bubbles (likely proliferated by the BAS), as well as fish. These materials all attracted birds to the area after a pier implosion. The avian monitors focused on determining the extent to which birds were attempting to prey on dead or moribund fish (strikes) on the surface of the water.

After each blast event, the avian monitors initiated 1-minute counts to tally bird strikes. The position of each avian monitor and monitoring zones are shown on Figures 5-1 through 5-6 in Chapter 5. The counts were repeated throughout the duration of the bird predation monitoring. The 1-minute counts stopped after no more birds were observed to be striking the water. Diving and surface-scavenging birds that appeared to scavenge fish from the surface were recorded as a strike count.

8.2. Monitoring Summary and Results

8.2.1. **Piers E7 and E8**

Bird predation monitoring began immediately after the implosion of Piers E7 and E8, at 10:36 a.m. The only bird species observed to strike in the vicinity of the former piers following the blast were gulls. Overall, bird predation activity was low. Gulls were observed investigating the vicinity of the former piers by flying low over the water and appearing to scout for prey; although some landed and immediately took off (recorded as a strike), most flew over and out of the blast area or landed and floated on the water's surface. The avian monitors at positions A2 and A3 performed 1-minute strike counts, while the avian monitor at position A1 performed 5-minute strike counts because of low levels of bird predation activity observed from that monitor's vantage point. The first strikes were noted between 10:37 and 10:42 a.m. by the avian monitor at A1 (five strikes recorded over a 5-minute period). Over the next 30 minutes, more gulls entered the area, reaching a peak of approximately 50 individuals. Although the number of individuals increased, bird predation activity remained low, with a peak of eight strikes per minute observed by the avian monitors at A2 between 10:47 and 10:48 a.m. and again between 10:52 and 10:53 a.m. The only confirmed sighting of a bird with a fish was recorded by an avian monitor at position A2, who observed a gull with a rock fish (*Sebastes* sp.) land on a piece of blast debris between strike counts. After 11:01 a.m., monitoring from the bike path and the Pier E3 footing stopped because of a lack of activity.

8.2.2. **Pier E6**

Bird predation monitoring began immediately after the implosion of Pier E6 at 10 a.m. The only bird species observed to strike or feed in the vicinity of the former piers following the blast were gulls. Overall, bird predation activity was very active relative to the previous implosion of Piers E7 and E8. Gulls were observed feeding on fish both inside and outside the debris boom. The first strikes were noted as early as 10:07 a.m. Over the next 25 to 30 minutes, more gulls entered the area, reaching a peak of approximately 50 to 60 individuals. From the bike path, birds were observed via spotting scope and binoculars to be actively feeding on small silver fish, which later were determined most likely to be anchovies (see description below of fish recovered). Bird predation was most intensive between approximately 10:10 and 10:20 a.m. Although strikes were not seen often, it was common to see gulls swimming in the debris area, feeding on floating fish for approximately 30 minutes following the blast.

8.2.3. **Piers E9 and E10**

Bird predation monitoring began immediately after the implosion of Piers E9 and E10 at 9:23 a.m. The only bird species observed to strike in the vicinity of the former piers following the blast were gulls. Following the blast, approximately 50 gulls began flying over the former location of Piers E9 and E10, with activity concentrated over the former location of Pier E9. Gulls were observed investigating the vicinity of the former piers by flying low over the water and appearing to scout for prey; although some landed and foraged for fish at the water's surface (recorded as a strike), most flew over and out of the blast area or landed and floated on the water's surface. The first strike was noted between 9:25 and 9:26 a.m. by the avian monitor at position A3 (one strike recorded). Over the next 20 minutes, more gulls entered the area, reaching a peak of approximately 100 individuals. Although the number of individuals increased, bird predation activity remained low, with a peak of 20 strikes per minute observed by the avian monitor at position A3 from 9:33 to 9:34 a.m. The avian monitor at position A1 was directly over the former location of Pier E9 during the monitoring and visually could identify four instances of birds eating fish; at a distance, fish species were difficult to identify, but it appeared that the gulls were eating a rockfish, a small silver fish (possibly jacksmelt), and a surfperch. Predation decreased between 9:40 and 10 a.m. Monitoring from the bike path stopped at 10:10 a.m., and monitoring from the Pier E6 footing stopped at 10:23 a.m. because of the lack of predation activity.

8.2.4. **Piers E11, E12, and E13**

Bird predation monitoring began immediately after the implosion of Piers E11 through E13 at 8:51 a.m. The only bird species observed to strike in the vicinity of the former piers following the blast were gulls. Within minutes of the blast, a flock of gulls (approximately 50 gulls) began flying over the former locations of Piers E11 through E13, with activity concentrated over the former locations of Piers E11 and E12. Gulls were observed investigating the vicinity of the former piers by flying low over the water and appearing to scout for prey; although some landed and foraged for fish at the water’s surface (recorded as a strike), most flew over and out of the blast area or landed and floated on the water’s surface. The first strike was noted around 8:52 a.m. by the avian monitor at position A2 (one strike recorded). Over the next 20 minutes, more gulls entered the area. Although the number of individuals increased, bird predation activity remained low, with a peak of 23 strikes per minute. Only one avian monitor visually confirmed an instance of birds eating fish. Predation/bird activity decreased from approximately 9:07 a.m. Monitoring from the bike path stopped at 9:20 a.m., and monitoring from the Pier E8 footing stopped at 9:27 a.m. because of the lack of predation activity.

8.2.5. **Piers E14, E15, and E16**

Bird predation monitoring began immediately after the implosion of Piers E14 through E16 at 7:59 a.m. The only bird species observed to strike in the vicinity of the former piers following the blast were gulls. Within minutes of the blast, a flock of gulls (approximately 50 gulls) began flying over the former location of Piers E14 through E16, with activity concentrated southwest of the former piers. Gulls were observed investigating the vicinity of the former piers by flying low over the water and appearing to scout for prey; although some landed and foraged for fish at the water’s surface (recorded as a strike), most flew over and out of the blast area or landed and floated on the water's surface. A California brown pelican was observed in the area; however, it was not foraging. The first strike was noted around 7:54 a.m. by the avian monitor at position A3 (15 strikes recorded). Over the next 10 minutes, more gulls entered the area. Although the number of individuals increased, bird predation activity remained low, with a peak of 15 strikes per minute. Predation/bird activity decreased from approximately 8 a.m. Monitoring from the bike path stopped at 8:05 a.m., and monitoring from the Pier E9 footing stopped at 8:15 a.m. because of the lack of predation activity.

8.2.6. **Piers E17 and E18**

Bird predation monitoring began immediately after the implosion of Piers E17 and E18 at 7:27 a.m. Avian monitors at positions A1, A2, and A3 collected data; the monitor at position A1 focused on the area around former Pier E18, the monitor at position A2 focused on the area around former Pier E17, and the monitor at position A3 focused on the area north of the former piers. The majority of bird species observed to strike in the vicinity of the former piers following the blast were gulls, including western gull and Heermann's gull (*Larus heermanni*); two California brown pelicans also were observed. Within minutes of the blast, gulls were observed to fly to the former location of Piers E17 and E18. A flock of gulls (approximately 50 to 100 gulls) began flying over the blast location, with activity concentrated north of the former piers. Gulls were observed investigating the vicinity of the former piers by flying low over the water and appearing to scout for prey; although some landed and foraged for fish at the water's surface (recorded as a strike), most flew over and out of the blast area or landed and floated on the water's surface. The first strikes were noted around 7:32 a.m. by avian monitors at position A1 (four strikes near former Pier E18) and position A3 (21 strikes near former Pier E17). Over the next 10 minutes, predation activity remained relatively high, peaking at 23 strikes per minute at 7:36 a.m. Greater bird predation activity was observed near former Pier E17. Two California brown pelicans were observed predating on fish at 7:33 a.m. Predation began to taper off at approximately 7:50 a.m. Monitoring from the bike path stopped at 8:09 a.m., and monitoring from the Pier E11 footing stopped at 8:06 a.m. because of the lack of predation activity.

Chapter 9. Fish Salvage

9.1. Fish Salvage Methods

To further understand the quantity, species, and nature of injury or mortality to fish, the biologists used boats to collect dead or moribund fish from the water for further examination, immediately after the implosions of Piers E6 through E18.

Fish salvage following the blasts was conducted by two dedicated boats, each with two biologists, as well as by the construction contractor within the containment booms encircling each pier. Following the blasts, the construction contractor began work to cleanup and contain debris from the area within the containment boom. Specially marked buckets were placed on each contractor skiff, so that collected fish could be held separately from other debris. The biologists navigated around the piers (when it was deemed safe to do so after the implosion) and collected any fish observed floating on the water surface, using long-handled nets. Fish also were collected from the debris management boats that were operated by the contractor within the debris containment booms surrounding the piers, and they were stored in a bucket for further identification and assessment by a biologist on shore. After fish collection on the water was completed, one boat proceeded to rendezvous with the contractor's barge, to collect the fish recovered within the containment booms.

All collected fish were brought back to Berth 9 for review by the project team. Collected fish were organized by size and species, and then were counted and photographed.

9.2. Fish Salvage Summary and Results

The results from the fish salvage effort, including size and number of individuals of each species collected, are included next. The results are organized by implosion date.

9.2.1. **Piers E7 and E8**

Before the blast, the fish salvage boats were north and south of Piers E7 and E8. The collection of fish within the containment booms started at approximately 10:45 a.m. and continued for approximately 60 minutes.

The current was moving to the south after the blast, pushing fish and blast debris in that direction. The biologists in the dedicated fish collection boat to the south proceeded to collect fish between approximately 700 and 1,500 feet (213 and 457 meters) south of the former Piers E7 and E8. The fish collection boat staged north of the former piers was relocated, to assist with fish collection to the south after it was confirmed that no injured fish or bird predation was occurring in its vicinity following the blast. Fish collection was performed until approximately 11:45 a.m.

In total, 88 individual fish were collected—16 fish from inside the containment boom and 72 from outside the containment boom. Seven species were collected, with brown rockfish (*Sebastes auriculatus*) being the most prevalent species (52 percent). The second most prevalent fish species was juvenile plainfin midshipman (*Porichthys notatus*); however, 26 of the 28 total captured were juveniles that were less than 30 mm in length. Other species collected included shiner surfperch (*Cymatogaster aggregata*), white surfperch (*Phanerodon furcatus*), black surfperch (*Embiotoca jacksoni*), rubberlip surfperch (*Rhacochilus toxotes*), and surf smelt (*Hypomesus pretiosus*). A summary of the fish collected is shown in Table 9-1. No FESA or CESA listed species was collected or observed.

Table 9-1. Piers E7 and E8 Fish Salvage Results

Species	Fish Size Category (fork length in millimeters [mm])	Number of Fish Outside Containment Boom (collected by biologists)	Number of Fish Inside Containment Boom (collected by contractor)	Total Number of Fish
Brown rockfish	less than 80 mm	28	0	28
	81–125 mm	2	1	3
	126–200 mm	2	2	4
	201–300 mm	5	5	10
	greater than 301 mm	1	0	1
Shiner surfperch	201–300 mm	1	0	1
White surfperch	126–200 mm	0	1	1
	201–300 mm	1	3	4
	greater than 301 mm	0	1	1
Black surfperch	81–125 mm	2	0	2
	greater than 301 mm	0	1	1
Rubberlip surfperch	greater than 301 mm	0	1	1
Plainfin midshipman	less than 80 mm	26	0	26
	201–300 mm	1	0	1
	greater than 301 mm	0	1	1
Surf smelt	less than 80 mm	3	0	3
Total		**72**	**16**	**88**

Source: Compiled by AECOM 2017

9.2.2. Pier E6

Before the blast, the fish salvage boats were north and south of Pier E6. The collection of fish within the containment booms started at 10:04 a.m. and continued for approximately 45 minutes.

The current was moving to the south after the blast, pushing fish and blast debris in that direction. The biologists in dedicated fish collection boat to the south proceeded to collect fish between approximately 700 and 2,000 feet (213 and 609 meters) south of the former Pier E6 location, starting at 10:06 a.m. The fish collection boat staged north of the former piers relocated to assist with fish collection to the south, after it was confirmed that no injured fish or bird predation was occurring in their vicinity following the blast. Fish collection was performed until approximately 10:45 a.m.

In total, 777 individual fish were collected—303 fish from inside the containment boom and 474 from outside the containment boom. Twelve species were collected, with northern anchovy (*Engraulis mordax*) being the most prevalent species (81 percent). A school of anchovy were believed to have moved through the area at the time of the blast and inadvertently to have been killed by the implosion. The second most prevalent fish species was brown rockfish (15.2 percent). Other species collected included shiner surfperch, rubberlip surfperch, black surfperch, plainfin midshipman, and topsmelt silverside (*Atherinops affinis*). A single yellowfin goby (*Acanthogobius flavimanus*), pacific herring (*Clupea pallasii*), and pile perch also were recovered after the blast. A summary of the fish collected is shown in Table 9-2. No FESA or CESA listed species was collected or observed.

Table 9-2. Pier E6 Fish Salvage Results

Species	Fish Size Category (fork length in millimeters [mm])	Number of Fish Outside Containment Boom (collected by biologists)	Number of Fish Inside Containment Boom (collected by contractor)	Total Number of Fish
Brown rockfish	less than 80 mm	46	27	73
	81–125 mm	15	11	26
	126–200 mm	3	9	12
	201–300 mm	4	2	6
	greater than 301 mm	1	0	1
Shiner surfperch	less than 80 mm	1	1	2
	81–125 mm	2	3	5
	126–200 mm	0	2	2
Black surfperch	81–125 mm	0	1	1
	126–200 mm	0	2	2
Rubberlip surfperch	81–125 mm	0	2	2
	greater than 301 mm	0	2	2
Pile perch	201–300 mm	0	1	1
Yellowfin goby	81–125 mm	0	1	1
Northern anchovy	less than 80 mm	40	19	59
	81–125 mm	351	219	570
Pacific herring	less than 80 mm	1	0	1
Plainfin midshipman	less than 80 mm	5	0	5
	126–200 mm	0	1	1
	201–300 mm	1	0	1
Topsmelt silverside	less than 80 mm	4	0	4
Total		**474**	**303**	**777**
Source: Compiled by AECOM 2017				

9.2.3. **Piers E9 and E10**

Before the blast, the fish salvage boats were south of Piers E9 and E10. The collection of fish within the containment booms started at 9:30 a.m. and continued for approximately 45 minutes.

The current was moving to the north after the blast, pushing fish and blast debris in that direction. After it was confirmed that no injured fish or bird predation was occurring in their vicinity following the blast, the fish collection boats relocated to the north and proceeded to collect fish between approximately 500 and 2,000 feet (152 and 609 meters) north of the former Piers E9 and E10. Fish collection was performed until approximately 10:15 a.m.

In total, 20 individual fish were collected—11 fish from inside the containment boom and nine from outside the containment boom. Eight species were collected, with brown rockfish being the most prevalent species (30 percent). The second most prevalent fish species was plainfin midshipman. Other species collected included shiner surfperch, black, surf smelt, and a single jack silverside (jacksmelt) (*Atherinopsis californiensis*). A summary of the fish collected is shown in Table 9-3. No FESA or CESA listed species was collected or observed.

Table 9-3. Piers E9 and E10 Fish Salvage Results

Species	Fish Size Category (fork length in millimeters [mm])	Number of Fish Outside Containment Boom (collected by biologists)	Number of Fish Inside Containment Boom (collected by contractor)	Total Number of Fish
Brown rockfish	less than 80 mm	2	0	2
	126–200 mm	1	1	2
	201–300 mm	0	2	2
Shiner surfperch	81–125 mm	1	1	2
	126–200 mm	0	1	1
Black surfperch	201–300 mm	0	2	2
Yellowfin goby	126–200 mm	0	1	1
Northern anchovy	81–125 mm	1	0	1
Jacksmelt	201–300 mm	0	1	1
Plainfin midshipman	less than 80 mm	3	0	3
	201-300 mm	0	2	2
Topsmelt silverside	less than 80 mm	1	0	1
Total		**9**	**11**	**20**
Source: Compiled by AECOM 2017				

9.2.4. **Piers E11, E12, and E13**

Before the blast, the fish salvage boats were north of Piers E11, E12, and E13. The collection of fish within the containment booms started at 8:51 a.m. and continued for approximately 50 minutes.

The current was moving to the south after the blast, pushing fish and blast debris in that direction. After it was confirmed that no injured fish or bird predation was occurring in their vicinity following the blast, the biologists relocated the fish collection boats to the south and proceeded to collect fish between approximately 500 and 1,500 feet (152 and 457 meters) south of the former Piers E11, E12, and E13. Fish collection was performed until approximately 9:40 a.m.

In total, 32 individual fish were collected—two fish from inside the containment boom and 30 from outside the containment boom. Eight species were collected, with juvenile plainfin midshipman being the most prevalent species (50 percent). The second most prevalent fish species was Pacific herring (22 percent). Other species collected included brown rockfish, jack silverside, shiner surfperch, black surfperch, topsmelt silverside, and northern anchovy. A summary of the fish collected is shown in Table 9-4. No FESA or CESA listed species was collected or observed.

Table 9-4. Piers E11, E12, and E13 Fish Salvage Results

Species	Fish Size Category (fork length in millimeters [mm])	Number of Fish Outside Containment Boom (collected by biologists)	Number of Fish Inside Containment Boom (collected by contractor)	Total Number of Fish
Brown rockfish	less than 80 mm	2	0	2
	81–125 mm	1	0	1
Shiner surfperch	81–125 mm	1	0	1
Black surfperch	201–300 mm	1	0	1
Northern anchovy	less than 80 mm	1	0	1
Pacific herring	81–125 mm	7	0	7
Jacksmelt	201-300 mm	0	2	2
Plainfin midshipman	less than 80 mm	16	0	16
Topsmelt silverside	less than 80 mm	1	0	1
Total		**30**	**2**	**32**
Source: Compiled by AECOM 2017				

9.2.5. **Piers E14, E15, and E16**

Before the blast, the fish salvage boats were north of Piers E14, E15, and E16. The collection of fish within the containment booms started at 8 a.m. and continued for approximately 60 minutes.

The current was moving to the south after the blast, pushing fish and blast debris in that direction. After it was confirmed that no injured fish or bird predation was occurring in their vicinity following the blast, the biologists relocated to the south and proceeded to collect fish between approximately 500 and 1,000 feet (152 and 304 meters) south of the former Piers E14, E15, and E16. Fish collection was performed until approximately 9 a.m.

Three individual fish were collected—two fish from inside the containment boom and one from outside the containment boom. Of the three individual specimens recovered, three different species were observed: one northern anchovy, one Pacific herring, and one striped bass (*Morone saxatalis*). A summary of the fish collected is shown in Table 9-5. No FESA or CESA listed species was collected or observed.

Table 9-5. Piers E14, E15, and E16 Fish Salvage Results

Species	Fish Size Category (fork length in millimeters [mm])	Number of Fish Outside Containment Boom (collected by biologists)	Number of Fish Inside Containment Boom (collected by contractor)	Total Number of Fish
Pacific herring	81–125 mm	0	1	1
Northern anchovy	less than 80 mm	1	0	1
Striped bass	greater than 301 mm	0	1	1
Total		**1**	**2**	**3**
Source: Compiled by AECOM 2017				

9.2.6. **Piers E17 and E18**

Before the blast, the fish salvage boats were north of Piers E17 and E18. The collection of fish within the containment booms started at 7:30 a.m. and continued for approximately 45 minutes.

The current was moving to the north after the blast, pushing fish and blast debris in that direction. After receiving clearance that it was safe to enter the 1,500-foot exclusion area after the blast, the biologists in the fish collection boats began searching for fish between approximately 500 and 1,000 feet (152 and 304 meters) north of the former Piers E17 and E18. Fish collection was performed until approximately 8:45 a.m.

In total, 53 individual fish were collected—two fish from inside the containment boom and the remainder from outside the containment boom. All of the specimens recovered were species that had been recovered during previous blast events, with brown rockfish being the most prevalent species (43 percent). A summary of the fish collected is shown in Table 9-6. No FESA or CESA listed species was collected or observed.

Table 9-6. Piers E17 and E18 Fish Salvage Results

Species	Size Category (fork length in millimeters [mm])	Number Outside Containment Boom (collected by biologists)	Number Inside Containment Boom (collected by contractor)	Total
Brown rockfish	less than 80 mm	13	1	14
	81–125 mm	8	0	8
	126–200 mm	1	0	1
Shiner surfperch	126–200 mm	2	0	2
White surfperch	201–300 mm	0	1	1
Northern anchovy	less than 80 mm	10	0	10
Striped bass	greater than 301 mm	1	0	1
Plainfin midshipman	less than 80 mm	2	0	2
	201–300 mm	1	0	1
Yellow-fin goby	less than 80 mm	13	0	13
Total		**51**	**2**	**53**
Source: Compiled by AECOM 2017				

9.3. Conclusions

The most prevalent species netted after the majority of the pier implosions were brown rockfish and northern anchovy. No FESA or CESA listed species was collected or observed after any of the implosions.

Chapter 10. Pacific Herring Monitoring

Per previous herring work waiver authorizations, CDFW required the Department to monitor for evidence of recent herring spawns within 1,640 feet (500 meters) of any activity that may affect schools of herring or spawning herring during the herring spawning season. No Pacific herring were collected after the implosions of Piers E6, E11–E12–E13, and E14–E15–E16.

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Chapter 11. Water Quality Monitoring

11.1. Monitoring Methods

The constituents of concern for implosions are pH and turbidity, and therefore these parameters are the focus of this chapter. Detailed tabulated water quality monitoring results, background readings, equipment validation and quality assurance, and processed monitoring data will be provided in a comprehensive water quality monitoring report that is expected to be available in spring 2018 and submitted under separate cover.

Monitoring methods for water quality during the 2016 implosion season were updated in 2017, to ensure the best methods were used (Department 2017a). A combination of methods was employed for each blast event. Monitoring methods used in 2017 included the following:

1. Fixed buoy monitoring;
2. Barge mounted sondes;
3. Dynamic plume mapping with drogues;
4. Static plume tracking; and
5. Eelgrass bed ESA monitoring.

In addition, sediment quality assessment sampling occurred, as described in Section 11.5. Monitoring types are described in further detail next.

11.1.1. Fixed Buoy Monitoring

Fixed buoy monitoring consisted of two fixed buoys within 100 feet (30 meters) of the imploded pier (or as close as safely possible). Buoys were north and south of the pier (i.e., based on the timing of the blast, the plume could travel in either direction depending on tidal currents). The fixed buoys provided continuous monitoring with multi-parameter sondes and data loggers for measuring turbidity, pH, dissolved oxygen, temperature, and conductivity at mid-depth of the water column.

11.1.2. Barge-Mounted Sondes

Barge-mounted sonde monitoring consisted of sondes mounted onto support barges within 100 feet (30 meters) of the imploded pier (or as closely as could be achieved safely). The barge-mounted sondes provided continuous monitoring data loggers for measuring turbidity, pH, dissolved oxygen, temperature, and conductivity at mid-depth.

One barge was located east of the pier, and one barge west of the pier. When multiple piers were being imploded, the sondes were placed based on field conditions. The Pier E6 sonde locations are shown in Figure 11-1.

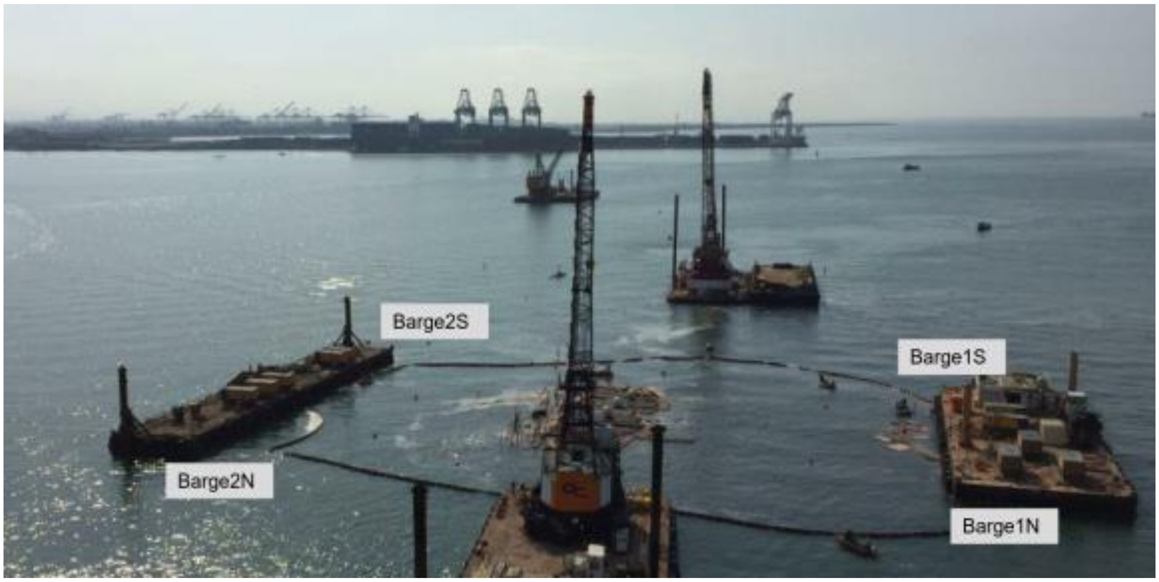

Figure 11-1. Barge-Mounted Sondes at Pier E6

11.1.3. **Dynamic Plume Mapping with Drogues**

Dynamic water column profiling was used to track the dispersion of the plumes generated by the pier implosions over an approximately 4-hour window, following the implosion. Using a towed monitoring array to capture a dynamic three-dimensional analysis of the plume, a sonde measured depth-averaged conductivity-temperature-depth (CTD), turbidity, pH, and dissolved oxygen. For each multiple-pier implosion event, the dynamic plume mapping occurred along the expected plume path from the easternmost pier, thereby enabling tracking of the plume and defining any possible interaction path with nearby ESAs. Monitoring the progress of the westernmost and easternmost plume paths created an enveloped area of all plumes generated by a multiple-pier blasting event.

Drogues, which are floating monitoring devices that travel with tidal currents, were used to track the movement of the plume with the current and guide the profiling effort, capturing geo-spatial data in real-time (Figure 11-2). A drogue tender deployed window-shade drogues, equipped with GPS and radio transmitters in pairs after the implosion.

Figure 11-2. Current Tracking Drift Drogue

11.1.4. Static Plume Tracking

Similar to dynamic plume tracking, static plume tracking was used to track the dispersion of the plumes generated by the pier implosions over an approximately 4-hour window, following each implosion. Static profiling included the raising and lowering of a sonde monitoring device from a stationary vessel. The sonde measured depth-averaged CTD, turbidity, pH, and dissolved oxygen. For each multiple-pier implosion event, static profiling occurred along the expected plume path from the westernmost pier, which was expected to generally parallel the travel path of the easternmost pier plume. The static plume mapping provided quality assurance for measurements taken by the dynamic plume-mapping boat.

11.1.5. Eelgrass Bed ESA Monitoring

Eelgrass beds are ESAs known to occur in the SFOBB Project vicinity. To confirm that the water quality in the vicinity of the eelgrass beds were not affected by the pier implosions, continuous autonomous monitoring buoys (Model YSI 6920 V2 sondes or similar model) were deployed in the water column at up to four eelgrass bed locations. The buoys measured turbidity, pH, temperature, and conductivity. Monitoring buoys were deployed east of Treasure Island, east of YBI, adjacent to the OTD, and near the western shore of the former Alameda Naval Air Station.

11.2. Monitoring Method Employed by Implosion Event

The monitoring types employed during each blast event are shown in Table 11-1. The combination of methods chosen for each type of implosion event was determined based on location of the pier(s) to be imploded in relation to an eelgrass bed, the number of piers being imploded, and the anticipated direction that the current would move immediately following the implosion event.

Table 11-1. Monitoring Methods by Event and Type

2017 Blast Event	Pier(s)	Monitoring Method: Types Conducted
September 2	E7, E8	Fixed Buoy Monitoring Barge-Mounted Sondes Eelgrass Monitoring
September 16	E6	Fixed Buoy Monitoring Barge-Mounted Sondes Eelgrass Monitoring
September 30	E9, E10	Dynamic Plume Mapping Static Plume Tracking Eelgrass Monitoring
October 14	E11, E12, E13	Barge-Mounted Sondes Dynamic Plume Mapping Static Plume Tracking Eelgrass Monitoring
October 28	E14, E15, E16	Barge-Mounted Sondes Dynamic Plume Mapping Static Plume Tracking Eelgrass Monitoring
November 11	E17, E18	Barge-Mounted Sondes Dynamic Plume Mapping Static Plume Tracking Eelgrass Monitoring

11.3. Sediment Quality Assessment

To monitor the effect of the implosion on benthic sediment habitat, a sediment quality assessment was conducted before and after the implosions. A random, stratified sampling design was implemented to test the spatial variability of sediment chemistry (i.e., trace metals and pH). The pre-implosion samples consisted of sample points near the pier locations where a Van Veen grab sampler scooped a sediment sample from the floor of the Bay. Sediment cores samples were prepared and sent for toxicity evaluation and measurement of concentration of metals. Post-implosion sediment samples were collected following the implosion event, as detailed next. Analytical results currently are being evaluated and the final results will be available in the final comprehensive water quality monitoring report, to be submitted under separate cover.

11.4. 2017 Water Quality Preliminary Results

The preliminary water quality results summary data for the 2017 implosions are shown in Table 11-2. All data are preliminary at this point. Turbidity and pH are the only constituents summarized in this document, because they are the primary constituents of concern. All measurements for pH and turbidity returned to background conditions within 4 hours from the time of the implosion. Final, detailed, tabulated water quality monitoring results will be provided in a comprehensive water quality monitoring report that is expected to be available in spring 2018.

Each of the implosion events showed preliminary results similar to results from previous implosions. The pH never ranged more than 1 pH unit from background, and although turbidity levels were observed to be well above background (the highest reaching 325 NTU) immediately following the implosions, the levels came down to background levels fairly quickly (all within 4 hours of the implosion). Water quality impacts were temporary and quickly dissipated, and no impacts on eelgrass beds were observed.

Table 11-2. pH and Turbidity Water Quality Parameter Results

Pier(s)	Date	General Background pH/ Turbidity Levels	Barge (surface)	Fixed Buoys WDR (100 feet) (water column)	Plume Mapping (water column)	Eelgrass (surface)
Piers E7, E8	Sept. 2		pH: 8.86 max (+.65 Δ) Turb.: 240 max To background: 1.5 hrs	pH: 8.3 max Turb.: 40 max To background: 1.5 hrs	Not measured	pH: ± 0.2 Δ Turb.: 7 max Remained at background
Pier E6	Sept.16		pH: 8.28 max (+.45Δ) Turb.: 325 max To background: ~1 hr	pH: 8.2 max Turb.: 42 max To background: ~1 hr	Not measured	pH: ± 0.2 Δ Turb.: 17 max Remained at background
Piers E9, E10	Sept. 30		Not measured	Not measured	pH: 8.9 max Turb.: 70 max To background: ~3.5 hrs	pH: ± 0.2 Δ Turb.: 14 max Remained at background
Piers E11, E12, E13	Oct. 14		pH: 8.75 max (+.79 Δ) Turb.: 168 max To background: 1.5 hrs	Not measured	pH: 9.0 max Turb.: 60 max To background: ~3.5 hrs	pH: ± 0.2 Δ Turb.: 22 max Remained at background
Piers E14, E15, E16	Oct. 28		pH: 8.52 max (+.68 Δ) Turb.: 185 max To background: ~1 hr	Not measured	Similar to Piers E9/E10 and Piers E11/E12/E13 Implosions	pH: ± 0.2 Δ Turb.: 20 max Remained at background
Piers E17, E18	Nov. 11		pH: 8.53 max (+0.67 Δ) Turb.: 205 max To background: ~1 hr	Not measured	pH: 8.6 max Turb.: 80 max To background: ~3.5 hrs	pH: ± 0.1 Δ Turb.: 20 max Remained at background

Source: compiled by Amec Foster Wheeler, 2018
Notes:
Turbidity units are measured in nephelometric units (NTU).
pH units are measured in standard pH units.
Δ = change from background

11.5. Sediment Quality Assessment Sampling Results

Sediment quality assessment results are pending and will be provided in the separate comprehensive water quality monitoring report.

11.6. Conclusions

Water quality monitoring results for the 2017 implosion events were similar to and consistent with the water quality monitoring results from the 2016 implosion events. As was observed after the 2016 implosions, after each 2017 implosion event, the plume rapidly dispersed, moving quickly with the current, and the water column returned to background conditions within a few hours. Eelgrass monitoring results were similar for all implosion events, and data levels stayed within the background values. Impacts on water quality were temporary and consistent with natural fluctuations in the Bay, including those seen during inclement weather. Drogue activity indicated that the currents, and therefore the plumes resulting from the implosions never reached the eelgrass beds, and data showed all water quality levels remained at or near background levels. Thus, no impacts on eelgrass beds were observed during the 2017 implosion season.

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Chapter 12. Hydrographic Surveys and Infill Monitoring

Hydrographic surveys were conducted using a small vessel with side-scan sonar equipment to map elevations of the Bay floor in the vicinity of Piers E6 through E18 before blast events, immediately after blast events, and after cleanup of blast-related equipment and accessible concrete debris. These surveys were used to confirm that the blast events were effective in collapsing the in-water portions of the marine foundations as designed, and to guide the subsequent cleanup efforts. In addition, the sonar scans were used to confirm that the removal of each structure to its respective removal limit was achieved. This chapter presents the results of these hydrographic surveys and provides the estimated volumes of material that was disposed upland and off-site and the volume of material left in-situ.

The Department has committed to conducting annual hydrographic surveys and sediment infill assessments of the scour pits and pier footprints at all former pier locations, to assure natural restoration of the Bay floor to mudline elevations. The reported results include a description of the estimated volume of sediment accretion and erosion at the former Pier E3 location from December 2015 to November 2017. Post-cleanup surveys done in 2017 for Piers E4 to E18 will establish a baseline for future sediment infill monitoring.

In 2016, Piers E4 and E5 removal limits were achieved as planned, with the exception of a few small areas. Pier E4 had high points along the western and eastern walls of the caisson. Pier E5 had small areas containing two high points at the northwestern and northeastern corners of the caisson, approximately 3 to 4 feet (0.9 and 1.2 meters) above Pier E5's removal limits. As the 2016 regulatory in-water work windows closed before these areas could be addressed, the Department confirmed that these remaining locations posed no risks to navigation or public safety, and concluded to address these locations in the following construction season. These small areas were removed in 2017 with specialized equipment to authorized removal limits, and post-cleanup surveys of Piers E4 and E5 will be used to establish a baseline for 2018 surveys.

To establish consistent monitoring methods for analyzing and reporting sediment infill results, the Department delineated the scour pit corresponding with the approximate mudline elevation adjacent to and outside each former pier location. These delineated scour pit areas will be used in future monitoring efforts to determine sediment infill and sediment erosion/settlement within a fixed area. The monitoring areas for each scour pit location are provided in Appendix C.

12.1. Monitoring Methods

12.1.1. Hydrographic Surveys

Hydrographic surveys were conducted by boat, using a multibeam sonar system and a GPS. Software packages were used to calibrate, collect, and process these survey datasets.

Surveys were conducted by eTrac Inc. The survey vessel “S/V Pulse” was used for data acquisition. An R2Sonic 2024 Multibeam Sonar was used to acquire sounding data. Positions were acquired using an Applanix POSMV Wavemaster GPS, with combined inertial positioning and motion reference. Acquisition hardware was interfaced with a QPS Qinsy Multibeam software package. Sound velocity corrections were obtained with an AML sound velocity profiler and applied to MBES data in real time.

Processing was performed using QPS Qinsy and Qimera software packages, and Hypack. Final images were created in AutoCAD Civil3D, Qimera, and Hypack.

Post-implosion surveys were performed several times each day for multiple days, leading up to the final survey of the area. Construction operations were directed with real-time acquisition and analysis of data. Maximum coverage was targeted to ensonify all possible obstructions and structures in the area surveyed. Times of best GPS and GLONASS constellation geometry were planned to obtain the highest accuracy surveys when beneath structures that tend to hamper satellite signals. The Applanix POSMV inertial positioning system was used for under-bridge data collection, which was attained even with decrease or loss of satellite coverage. Position data was post-processed with Applanix POSPAC software, to attain higher accuracies.

Passes were made by the survey vessel at slow, consistent speeds, with minimum steering corrections, following established perpendicular transects to allow the system to most effectively use inertial inputs from the gyro to capture data.

12.1.2. Debris Management

During debris management after blasting at all former pier sites, a crane-mounted clamshell bucket and barge was used to remove concrete and rebar debris. Debris was weighed after removal at upland recycling facilities receiving stations, and that weight was used to estimate the total cubic yards of concrete removed. A bulking factor of 1.6

was applied to all concrete volume estimates. Concrete volume for each structure was estimated and the difference between the upland volume and the original estimate was assumed to be the volume that remained in-situ below approved removal limits.

12.2. Monitoring Summary and Results

12.2.1. Post -Blast Removal Confirmation

Site conditions at Piers E4 to E18 before removal and after controlled blasting and debris management to remove pier material to below removal limits are shown in the figures provided in Appendix D. After each blast event, debris was removed to or below planned and accepted limits for all pier footprint areas.

Removal limits and dates when these limits were achieved at each former pier location are shown in Table 12-1.

Table 12-1. Approximate Mudline Elevations, Removal Elevations and Confirmed Removal Dates

Pier Number	Mudline Elevation (feet)	Accepted Removal Limits (3 feet below mudline) (feet)	Confirmed Removal Date
E4	-45.0	-48.0	August 30, 2017
E5	-47.5	-50.5	September 1, 2017
E6	-40.0	-43.0	October 13, 2017
E7	-28.0	-31.0	September 14, 2017
E8	-19.0	-22.0	September 8, 2017
E9	-17.5	-20.5	October 11, 2017
E10	-18.0	-21.0	October 11, 2017
E11	-14.0	-17.0	October 20, 2017
E12	-14.0	-17.0	October 20, 2017
E13	-14.0	-17.0	October 19, 2017
E14	-15.0	-18.0	November 6, 2017
E15	-12.5	-15.5	November 6, 2017
E16	-12.5	-15.5	November 6, 2017
E17	-12.5	-15.5	November 15, 2017
E18	-12.5	-15.5	November 17, 2017

Note: All elevations use National Geodetic Vertical Datum 1929.

Source: Caltrans 2018; compiled by AECOM in 2018

As noted in Table 12-1 above, the Piers E4 and E5 sites were revisited in 2017, to complete removal of high points of remnant pier and debris to below authorized removal limits. A summary table removal and survey actions at the Piers E4 and E5 sites is shown in Table 12-2.

Table 12-2. Pier E4 and Pier E5 Summary of Actions

Pier	Action	Date
Pier E4	Pre-Implosion Survey	October 12, 2016
	Controlled Implosion	October 29, 2016
	Post-Implosion Survey	October 31, 2016
	Post-Cleanup Survey 1	November 16, 2016
	Pre-Cleanup Survey	August 28, 2017
	Post Cleanup Survey 2	August 30, 2017
Pier E5	Pre-Implosion Survey	October 12, 2016
	Controlled Implosion	October 15, 2016
	Post-Implosion Survey	October 14, 2016
	Post-Cleanup Survey 1	November 16, 2017
	Pre-Cleanup Survey	August 28, 2017
	Post Cleanup Survey 2	September 1, 2017

12.2.2. **Marine Foundation Infill Monitoring**

As discussed above, the SFOBB Project has committed to monitoring the remaining scour pit and pier footprint areas at former pier locations, to assure that natural restoration of the Bay floor to mudline elevations is progressing. The SFOBB original east span's Pier E3 marine foundation was imploded on November 14, 2015, and cleanup activities were completed on December 10, 2015. Hydrographic surveys of Pier E3 were performed before the implosion, immediately after controlled implosion, and on completion of cleanup activities. The results of the sediment infill analysis from observations taken between December 2015 and December 2016 at the Pier E3 scour pit were included in the 2016 Post-Blast Report (Department 2016). The scour pit and caisson footprint area that was surveyed is approximately 2.9 acres (approximately 127,000 square feet [1.18 hectares]), and all data points were extracted using the same geographic area. The following summarizes previous reporting and updates this information with additional data, collected in November 2017.

Hydrographic surveys were conducted in December 2015, June 2016, December 2016, and November 2017, to evaluate sediment infill. Two surveys were conducted in 2016 because the Department had an opportunity to collect an additional data point. The Department plans to conduct a single annual survey for all remaining monitoring efforts. Hydrographic survey data that was collected on these dates were analyzed within a boundary delineated around the Pier E3 scour pit and caisson footprint that corresponds with the approximate mudline elevation adjacent to and outside the Pier E3 scour pit (Appendix C). A comparison of hydrographic survey images and data collected in December 2015, June 2016, December 2016, and November 2017 shows that over an approximately 2-year period, the former Pier E3 scour pit and caisson footprint is filling in naturally with the Bay sediment.

12.2.2.1. JUNE 2016 AND DECEMBER 2016 INFILL MONITORING

In June 2016 and December 2016, hydrographic surveys were conducted of the Bay floor in the vicinity of the former Pier E3 location. The results of these surveys were compared to their respective preceding hydrographic surveys, to determine infill and erosion sediment quantities. These results showed substantial infill of the Bay sediment in the scour pit and caisson footprint at the former Pier E3 location. These results were detailed in the 2016 Post-Blast Report for Piers E4 and E5 (Department 2016) and are paraphrased here.

The observed sediment accretion and erosion at the Pier E3 scour pit between December 2015 and December 2016 included approximately 3,665 cubic yards of new sediment deposited and 435 cubic yards of erosion/settlement, for a net gain of 3,230 cubic yards of sediment infill.

12.2.2.2. PIER E3 INFILL MONITORING

In November 2017, hydrographic surveys of the Bay floor at the former Pier E3 location indicated that between December 2016 and December 2017, approximately 140 cubic yards of sediment accreted within the delineated limits of the scour pit. During the same period, some small, localized areas eroded in the scour pit, resulting in the erosion of approximately 530 cubic yards of sediment. The results indicate a small net reduction in sediment input within the monitored area, with a net of -390 cubic yards of sediment.

An increase in erosion and settlement at this location could be driven by multiple factors, including the nature of the site being monitored. The remaining Pier E3 caisson footprint is made of deep hollow voids; as concrete debris fell into these remaining voids, sediment build-up on the debris likely is causing small collapse events into the voids. When surveying the caisson footprint, these collapse events would be reported as a net loss of sediment. Erosion also could be attributed to some of the higher mounds of debris (that were piled up within the caisson footprint of the former Pier E3) being knocked down and spread out, sediment sliding down and filling in the hollow pier cells below the mudline, some portions of the Bay mud being moved from vector changes in the topography after the removal of the pier, or natural compaction and settlement. The

Department expects this area to remain dynamic, until the collapse of concrete debris and settlement of sediment within the caisson footprint of Pier E3 stabilizes.

The observed sediment accretion and erosion at the Pier E3 scour pit and caisson footprint between December 2015 and December 2017 included approximately 3,805 cubic yards of new sediment deposited and 965 cubic yards of erosion/settlement, for a net gain of 2,840 cubic yards sediment infill to date after the removal of Pier E3.

A summary of the sediment input at the Pier E3 scour pit and caisson footprint is shown in Table 12-3. The data for these results show a continued trend of sediment accretion, accompanied by a small volume of erosion and/or settlement. These dynamics are expected and demonstrate a net gain as the site continues to fill with the Bay sediment. A survey will be conducted at this site in 2018, and at Piers E4 to E18, and the results from that survey will be reported to the SFOBB Project's environmental regulators.

Table 12-3. Pier E3 Cumulative Sediment Input Summary

Survey Dates	Total Accretion to Date (cubic yards)	Total Erosion/Settlement to Date (cubic yards)	Total Net to Date (cubic yards)
December 2015	0	0	0
June 2016	2580	-85	2495
December 2016	3665	-435	3230
June 20117	3805	-965	2840

12.2.2.3. Pier E4 and Pier E5 Infill Monitoring

As described above, the Piers E4 and E5 sites were disturbed when they were revisited in 2017, to complete debris removal to planned elevations. Therefore, the baseline for these locations will be reset from the December 2016 data point to the November 2017 data point. This means that the first round of reportable data that can be used in future analysis effectively will be established during the upcoming 2018 surveys. However, the Department collected pre-cleanup survey data in August 2017, before site disturbance from 2017 debris removal activities.

In August 2017, hydrographic surveys of the Bay floor at the former Pier E4 location indicated that between December 2016 and August 2017, approximately 1,895 cubic yards of sediment accreted within the delineated limits of the scour pit. During the same period, some small, localized areas eroded within the scour pit and caisson footprint, resulting in the erosion of approximately 215 cubic yards of sediment. This resulted in a net sediment infill volume of approximately 1,680 cubic yards.

In August 2017, hydrographic surveys of the Bay floor at the former Pier E5 location indicated that between December 2016 and August 2017, approximately 340 cubic yards of sediment accreted within the delineated limits of the scour pit and caisson footprint. During the same period, some small, localized areas eroded within the scour pit, resulting in the erosion of approximately 125 cubic yards of sediment. This resulted in a net sediment infill volume of approximately 215 cubic yards.

These data for Piers E4 and E5 are presented here for discussion only and will not be included in future reporting documents. The Pier E4 scour pit showed a large input of sediment, similar to what initially was seen at Pier E3. Conversely, data collected at the former Pier E5 scour pit shows a relatively small amount of sediment input during this same period. The Department infers from this data that similar trends of dynamic accretion results will be observed at the former locations of Piers E4 to E18 during future infill monitoring.

12.2.3. **Debris Management**

Site restoration, to manage post-blast debris to required removal limits, was initiated following implosions of Piers E6 through E18. Surveys showing site conditions at each former pier location before and after debris management are provided in Appendix D.

A total of approximately 11,420 cubic yards of rubble was disposed in-situ below accepted removal elevations at Piers E6 through E18. Approximately 26,090 cubic yards of rubble was disposed off-site. In-situ and upland concrete disposal volumes for Piers E6 through E18 are shown in Table 12-4 with the concrete disposal volumes previously reported for Piers E4 and E5. These concrete quantities include a bulking factor of 1.6. The bulking factor is the ratio applied to material that is solid to estimate volume of the same weight of material after it has been broken up.

Table 12-4. Piers E6 through E18 In-situ and Off-site Concrete Disposal Volumes

Pier Sites	Bulked Volume of Concrete Disposed Off-site (cubic yards)	Bulked Volume of Concrete In-Situ (cubic yards)
E4/E5	3,450	12,760
E6 to E18	26,090	11,420
Total	29,540	24,180
Note: All volumes assume a 1.6 Bulking Factor		

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Chapter 13. Summary and Lessons Learned

The controlled implosions of Piers E6 through E18 have proved to be successful, based on the measured hydroacoustics results and marine mammal, avian, and fisheries monitoring results. Lessons learned from the 2015 Pier E3 Demonstration Project and the 2016 implosion events at Piers E4 and E5 (Department 2015, 2016) were incorporated into the planning for the implosion events in 2017. The following are the summary highlights of the 2017 implosions:

- Safety was top priority. No injuries occurred to project personnel or the public.
- Based on the positive results from the removal of Piers E3, E4, and E5, the Department used controlled implosions in 2017 to implode Piers E6 through E18, reducing the originally proposed in-water work duration by a year.
- In 2017, some piers were imploded as multiple-pier implosion events over the course of a total of six events within the implosion work window. During multiple-pier implosion events, two to three piers were imploded sequentially.
- All piers were removed to the desired depths, and cleanup activities were completed by November 30, 2017.
- The BAS appeared to be highly effective in reducing sound and pressure levels, similar to previous implosion events.
- Measured peak pressure and cSEL levels were lower than modeled.
- No take of FESA or CESA listed fish species occurred.
- No take of bird species occurred.
- No Level A take of marine mammals occurred; Level B take occurred but was under authorized limits.
- Data indicated that all water quality levels remained at or near background levels at the eelgrass beds; thus, no impacts on eelgrass beds were observed during the 2017 implosion season.
- Water quality results indicated temporary impacts on the Bay water quality, and all levels returned to background conditions within 2 to 4 hours.

During the implosion events in 2017, the Department continued to look for ways to improve efficiency and effectiveness, to continue the successful implementation of controlled implosions while minimizing impacts on the environment. The following is a summary of the lessons learned during the 2017 implosion season, which should be considered for future implosion events:

- Bird cannons need to be triggered multiple times before the blast, to be most effective at flushing birds from the pier caps.
- The use of a UAV is effective at flushing non-listed bird species from the pier caps.
- Hydroacoustic monitoring can continue to be scaled down to appropriate production levels while maintaining redundancy, to assure capture of usable data.

Chapter 14. References

California Department of Transportation (Department). 2015. *SFOBB Project Pier E3 Demonstration Project Biological Monitoring Programs*

———.2016 (May). *Final SFOBB Pier E3 Demonstration Project Report.*

———. 2017a. (June). *Sampling and Analysis Plan, Water Quality Monitoring, Controlled Underwater Blasting of Piers E6 to E18.*

———. 2017b. (June). *SFOBB Marine Foundation Removal Project–Final Biological Monitoring Programs* (2017 Biological Monitoring Program). San Francisco–Oakland Bay Bridge East Span Seismic Safety Project, Pier E4-E18 Demolition.

Finneran, J.J. and A.K. Jenkins. 2012. *Criteria and Thresholds for U.S. Navy Acoustics and Explosive Effects Analysis.* U.S. Department of the Navy.

Fisheries Hydroacoustic Working Group (FHWG). 2008 (June 12). *Agreement in Principal for Interim Criteria for Injury to Fish from Pile Driving Activities*. Memorandum. Available: http://www.dot.ca.gov/hq/env/ bio/fisheries_bioacoustics.htm. Accessed November 29, 2016.

Golden Gate Cetacean Research (GGCR). 2017 (September–November). Unpublished data. San Francisco, CA.

National Marine Fisheries Service (NMFS). 2012. (February 6) *Supplemental Biological Opinion for the San Francisco-Oakland Bay Bridge East Span Seismic Project, located in the San Francisco Bay, San Francisco, California.* NMFS No: F/SWRJ20lli05965

———. 2015. *Supplemental Biological Opinion and Conference Opinion. San Francisco–Oakland Bay Bridge Pier E3 Demonstration Project.* NMFS Consultation Number WCR-2015-2708.

———. 2016a. (August). *Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Re-initiation of the San Francisco-Oakland Bay Bridge Seismic Safety Project to Address Removal of Piers E4–E18 through the Use of Underwater Explosives.* NMFS No WCR-2016-5024

———.2016b. *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts*. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-55.

———.2017 (July 13). *Incidental Harassment Authorization: California Department of Transportation San Francisco–Oakland Bay Bridge*. 82 Federal Register 35510, July 31, 2017.

San Francisco Bay Regional Water Quality Control Board (RWQCB). 2002 (January). Waste Discharge Requirements for California Department of Transportation Bay Bridge East Span Seismic Safety Project. Board Order No. R2-2002-0011.

Washington State Department of Transportation (WSDOT). 2014. Marbled Murrelet Effects Thresholds. In *WSDOT Biological Assessment Guidance, Noise Assessment Guidance*. Available: http://www.wsdot.wa.gov/NR/rdonlyres/68220CAF-6C3B-4BC9-A54B-E98C3DA8BE41/0/MamuThresholds.pdf.

PERSONAL COMMUNICATIONS

Keener, W. Researcher, Golden Gate Cetacean Research, San Francisco, California. September–November 2017—personal communications to AECOM's SFOBB Project team.

The Marine Mammal Center (TMMC). Sausalito, California. D. Zahniser, Operations Manager; E. Hanahoe, Stranding Coordinator; staff veterinarian; stranding volunteers. September–November 2017—personal communications to AECOM's SFOBB Project team.

Appendix A
Marine Mammal Sightings Summary Tables

Appendix B
Fish Assemblage Results

Appendix C
Monitoring Areas for Scour Pits

Appendix D
Hydrographic Survey of Piers E4 through E18